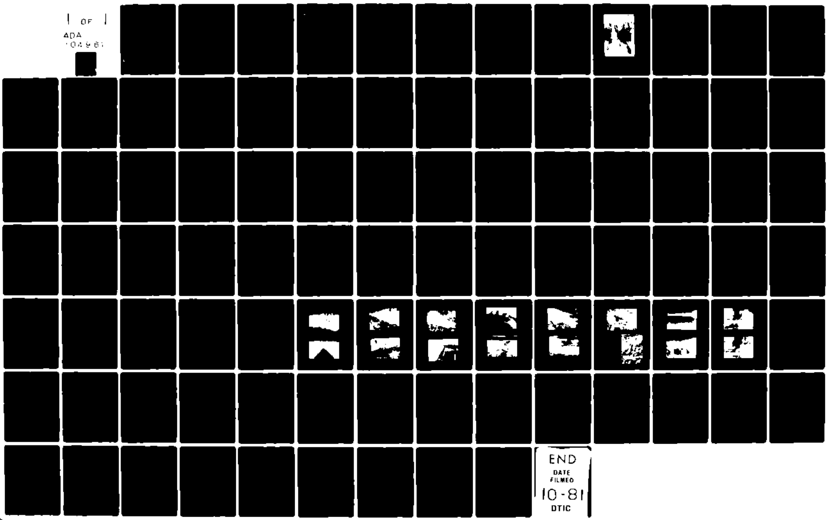
AD-A104 961 PRC CONSOER TOWNSEND INC ST LOUIS MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. CLEAR LAKE DAM (MO 30437), MISSISS--ETC(U)
JUL 81 W G SHIFRIN DACW43-81-C-0063

UNCLASSIFIED NL

1 OF 1
ADA
104961



LEVEL

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

AD A104961

CLEAR LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO. 30437

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JULY 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE — READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	
2. GOVT ACCESSION NO.	AD-A104961
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	Phase I Dam Inspection Report National Dam Safety Program Clear Lake Dam (MO 30437) Jefferson County, Missouri
5. TYPE OF REPORT & PERIOD COVERED	9 Final Report.
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	Consoer, Townsend and Associates, Ltd.
8. CONTRACT OR GRANT NUMBER(s)	DACW43-81-C-0063
9. PERFORMING ORGANIZATION NAME AND ADDRESS	U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS	U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101
12. REPORT DATE	July 1981
13. NUMBER OF PAGES	Approximately 75
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	National Dam Safety Program. Clear Lake Dam (MO 30437), Mississippi - Kaskaskia - St. Louis Basin, Jefferson County, Missouri. Phase I Inspection Report.
15. SECURITY CLASS. (of this report)	UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)	Approved for release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)	
18. SUPPLEMENTARY NOTES	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)	Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

411255

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Clear Lake Dam (Mo. 30437) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Clear Lake Dam (Mo. 30437).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. The spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED ______________________ 23 JUL 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED ______________________ 24 JUL 1981
Colonel, CE, Commanding — Date

CLEAR LAKE DAM

JEFFERSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30437

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY

PRC CONSOER TOWNSEND, INC.

ST. LOUIS, MISSOURI

AND

PRC ENGINEERING CONSULTANTS, INC.

ENGLEWOOD, COLORADO

A JOINT VENTURE

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

JULY 1981

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Clear Lake Dam, Missouri Inventory No. 30437
State Located:	Missouri
County Located:	Jefferson
Stream:	Unnamed tributary of Joachim Creek
Date of Inspection:	May 7, 1981

Assessment of General Condition

Clear Lake Dam was inspected by the engineering firms of PRC Consoer Townsend, Inc. of St. Louis, Missouri, and PRC Engineering Consultants, Inc. of Englewood, Colorado, (A Joint Venture) in accordance with the U.S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Located within the estimated damage zone of two miles downstream of the dam are at least three dwellings, one building, and a county highway (Highway V), which parallels Joachim Creek, all of which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Clear Lake Dam is in the small size classification since it is 29.9 feet high and has a maximum reservoir impoundment of 193 acre-feet.

The inspection and evaluation indicate that the spillway system of Clear Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Clear Lake Dam being a small size dam with a high hazard potential is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping the dam. Considering the small number of dwellings downstream of the dam, one-half of the Probable Maximum Flood is considered the appropriate spillway design flood for Clear Lake Dam. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. It was determined that the reservoir/spillway system can accommodate approximately 20 percent of the Probable Maximum Flood without overtopping the dam. The evaluation also indicates that the reservoir/spillway system will accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

The overall condition of the dam appears to be fair; however, the three areas of possible seepage observed along the downstream slope, including the sloughing of the slope in these areas, could jeopardize the safety of the dam. The areas of possible seepage and the undermining of the outfall of the spillway slab were two deficiencies noted that will require prompt attention. Other deficiencies noted by the inspection team, which will require remedial measures, included: the cracking of the concrete slab; the leakage under the concrete slab; the severe erosion and debris in the discharge channel; the erosion of the upstream slope due to wave action; the unmaintained vegetative cover and trees on the embankment; and a lack of a maintenance schedule. There exists a need for periodic inspection by a qualified engineer. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above. The following items should be pursued on a high priority basis: increasing the spillway capacity; further investigation of the three areas of possible seepage; and

repairing the undermining of the spillway slab. All other remedial measures should be accomplished within a reasonable period of time.

Walter G. Shifrin, P.E.

STATE OF MISSOURI
WALTER
G SHIFRIN
NUMBER
E-8834
REGISTERED PROFESSIONAL ENGINEER

Overview of Clear Lake Dam

NATIONAL DAM SAFETY PROGRAM

CLEAR LAKE DAM, I.D. No. 30437

TABLE OF CONTENTS

TABLE OF CONTENTS

(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF PLATES

APPENDICES

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CLEAR LAKE DAM, Missouri Inv. No. 30437

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Clear Lake Dam was carried out under Contract DACW 43-81-C-0063 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of PRC Consoer Townsend, Inc. of St. Louis, Missouri, and PRC Engineering Consultants, Inc. of Englewood, Colorado, (A Joint Venture).

b. Purpose of Inspection

The visual inspection of Clear Lake Dam was made on May 7, 1981. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, presents a summary of visual observations made during the field inspection, presents an assessment of hydrologic and hydraulic conditions at the site and of the structural adequacy

of the various project features, and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that in this report reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the west abutment or side, and right to the east abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase I Dam Inspection.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based upon observations and measurements made during the visual inspection and conversations with Mr. Paul N. Shy. Mr. Shy designed and constructed the dam. No design or "as-built" drawings for the dam or appurtenant structures were available.

The dam is a homogeneous rolled, earthfill structure with a 12-foot-wide core trench excavated to solid bedrock, according to Mr. Shy. The alignment of the dam is straight between earth abutments. A plan and elevation of the dam are shown on Plate 4 and

Photos 1 through 3 show views of the dam. The top of dam has a length of 450 feet between the right abutment and the spillway. The minimum elevation of the top of dam was found to be 713.5 feet above mean sea level (M.S.L.) at the spillway. From the spillway, the top of dam slopes upward to a point 140 feet from the right abutment with a rise in elevation of two feet. The top of dam was surveyed to be level for the next 120 feet. For the last 20 feet of the dam, the top of dam slopes upward with a rise in elevation of 2.5 feet. The embankment has a top width of 12 feet and a maximum structural height of 29.9 feet. The downstream slope was measured to be 1 vertical to 2 horizontal (1V to 2H). The upstream slope was measured to be 1V to 1.5H above the water surface on the day of the inspection.

There is only one spillway at this damsite, which consists of a concrete-lined open channel located in the left abutment. The control section of the spillway is a concrete weir situated at the inlet to the spillway channel (see Photo 6). The weir crest is 85 feet long and varies in width between 1.8 and 2.3 feet. The assumed crest elevation of the weir is 710.0 feet above M.S.L. At the centerline of the spillway, the top of the weir is 1.4 feet above the invert of the concrete spillway channel. An access road, which crosses the dam embankment, passes through the spillway channel just downstream of the weir. At this point, the channel has a bottom width of 60 feet with side slopes of 1V to 10H. At the outfall of the spillway channel, the channel is 2.5 feet deep and has a bottom width of 25 feet with side slopes of 1V to 8H and 1V to 5.4H on the left and right sides, respectively. At the outfall of the concrete spillway slab, the channel drops into a discharge channel, which is founded on bedrock (see Photo 10). From the outfall of the spillway channel, the discharge channel extends about 50 feet downstream to a point where the channel makes a 90-degree bend. The channel then parallels the dam axis until it enters a small pond located directly downstream of the dam (see Photo 14).

No low-level outlet is provided for this dam.

b. Location

Clear Lake Dam is located in Jefferson County in the State of Missouri on an unnamed tributary of Joachim Creek. The location of the dam on the 7.5 minute series of the U.S. Geological Survey maps is found in the northwest quadrant of Section 36 of Township 39 North, Range 4 East, of the Vineland, Missouri Quadrangle Sheet (Advance Print, see Plate 2). The dam is located approximately 5.5 miles southeast of De Soto (see Plate 1).

c. Size Classification

The maximum reservoir impoundment of Clear Lake Dam is 193 acre-feet. This is less than 1,000 acre-feet but more than 50 acre-feet, which would classify it as a "small" size dam. The maximum height of the dam of 29.9 feet is less than 40 feet and greater than 25 feet, which also classifies it as a "small" size dam. The size classification is determined by either the storage or height, whichever gives the larger size category. Therefore, the size classification is determined to fall within the "small" category, according to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineer.

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. From a visual inspection of the downstream area, our findings concur with this classification. Located within the estimated damage zone, which extends approximately two miles downstream of the dam, are at least three dwellings, one building, and a county highway (Highway V), which parallels Joachim Creek (see Photos 15 and 16).

e. Ownership

Clear Lake Dam is privately owned by the Lake Land Retreat Property Owners Association. The mailing address is as follows: Lake Land Retreat Property Owners Association, c/o Mr. Robert Sells, President, Lake Land Retreat, Rural Route 3, De Soto, Missouri, 63020.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use as a private lake.

g. Design and Construction History

According to Mr. Paul N. Shy, the original owner of Clear Lake Dam, the dam was designed and constructed by his own construction company during 1960 and 1961. No drawings or specifications pertaining to the design or construction of the dam were available.

The following information, which pertains to the construction of the dam, was obtained from Mr. Shy. The dam was constructed using rubber-tired scrapers and bulldozers. The embankment material was placed on the fill in thin layers and compaction of the material was achieved by the activity of the earthmoving equipment; however, no compaction control was employed. Material used for the homogeneous embankment was a fine clay borrowed from the reservoir area. A 12-foot-wide core trench was excavated along the axis of the dam to solid bedrock. Concrete used in the spillway was reinforced with wire mesh, and a one-foot-deep cutoff wall was provided below the weir wall. According to Mr. Sells, the Property Owners Association extended the cutoff wall about one or two years ago in an attempt to stop seepage under the spillway slab. The seepage still exists; however, the volume of discharge has been reduced, according to Mr. Sells.

h. Normal Operational Procedures

Normal operational procedure is to allow the reservoir to remain as full as possible. The water level is controlled by rainfall, runoff, evaporation, seepage and the crest elevation of the spillway weir.

1.3 Pertinent Data

a. Drainage Area (square miles): 1.65

b. Discharge at Damsite

Estimated experienced maximum flood (cfs): 495

Estimated ungated spillway capacity with reservoir at top of dam elevation (cfs): 1,954

c. Elevation (Feet above M.S.L.)

Top of dam (minimum): 713.5

Spillway crest: . . . . 710.0 (assumed)*

Normal Pool: 710.0

Maximum Experienced Pool: 711.5

Observed Pool: 709.8

d. Reservoir

Length of pool with water surface at top of dam elevation (feet): 1,300

e. Storage (Acre-Feet)

Top of dam (minimum): 193

Spillway crest: 144

Normal Pool: 144

Maximum Experienced Pool: 165

Observed Pool: 141

f. Reservoir Surfaces (Acres)

Top of dam (minimum): 15

Spillway crest: 13

Normal Pool: 13

Maximum Experienced Pool: 14

Observed Pool: 13

g. Dam

Type:. Rolled, Earthfill

Length:. . . . . 450 feet

Structural Height: . . . . 29.9 feet

Hydraulic Height**:. . . . . 29.9 feet

Top width: . . . . 12 feet

Side slopes:

Downstream. . . . . 1V to 2H (measured)

Upstream. . . . . 1V to 1.5H (from the top of dam to the elevation of the water surface on the day of the inspection)

Zoning:. . . . . Homogeneous

Impervious core: . . . . N.A.

Cutoff:. . . . . A core trench excavated to bedrock, according to Mr. Shy

Grout curtain: . . . . None

Volume:. . . . . 24,200 cu.yds. (estimated)

h. Diversion and Regulating Tunnel. . . . .None

i. Spillway

Type:. A concrete-lined open channel with a weir inlet, uncontrolled

Location:. . . . . Left abutment

Length of crest: . . . . 85 feet

Crest Elevation (feet above M.S.L.): . 710.0 (assumed)

j. Regulating Outlets . . . . None

* The crest elevation of the spillway is assumed to be the elevation of the reservoir as shown on the U.S.G.S. Vineland, Missouri Quadrangle topographic map (Advance Print). The elevations of other features of the dam are obtained by using this elevation and field measurements.

** The hydraulic height of the dam is the vertical distance from the lowest point on the downstream toe to the top of dam or the maximum water surface, if below the top of dam.

SECTION 2: ENGINEERING DATA

2.1 Design

No design drawings or data are available for Clear Lake Dam.

2.2 Construction

No construction records or data are available relative to the construction of the dam, other than the construction history given in Section 1.2g.

2.3 Operation

No documented operational records or data are available for the dam.

2.4 Evaluation

a. Availability

The availability of engineering data consists only of the State Geological Maps, a general soil map of the State of Missouri published by the Soil Conservation Service, and U.S.G.S. Quadrangle Sheets.

b. Adequacy

The lack of engineering data did not allow for a definitive review and evaluation. The conclusions presented in this report are based on field measurements, past performance and present condition of the dam. The available data including the field measurements taken by the field inspection team are considered

adequate to evaluate the hydraulic and hydrologic capabilities of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

No valid engineering data pertaining to the design or construction of the dam were available.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Clear Lake Dam was made on May 7, 1981. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Mark Haynes, P.E.	PRC Engineering Consultants, Inc.	Soils
Jerry Kenny	PRC Engineering Consultants, Inc.	Hydraulics and Hydrology
James Nettum, P.E.	PRC Engineering Consultants, Inc.	Civil-Structural and Mechanical
Razi Quraishi, R.P.G.	PRC Engineering Consultants, Inc.	Geology
Rupp Reitz	PRC Consoer Townsend, Inc.	Civil-Structural

Specific observations are discussed below.

b. Dam

The overall condition of the dam appears to be fair; however, some items of concern were observed and are described below.

The top of dam supports a gravel access road used by local residents to gain access to their homes (see Photo 2). Outside of the access road, the top of dam has a vegetative covering. The gravel surfacing and vegetative covering appear to provide adequate erosion protection against surface runoff, for no erosion was evident. No damage due to vehicular traffic across the dam was seen; however, in a few areas, patches of asphalt, which appeared to have been used to fill in potholes, were observed. No depressions or cracks indicating a settlement of the embankment were apparent. The variation in elevation across the top of dam did not appear to be due to an instability of the embankment. No significant deviation in the horizontal alignment was apparent. According to Mr. Shy, the dam has never been overtopped and no evidence indicating the contrary was observed.

The upstream slope of the dam is not protected by riprap; consequently, some damage due to wave action was observed on the slope. Near vertical scarps up to two feet high were observed in some areas above the normal water surface level. A small bench was observed just below the normal water surface level, which also appeared to have been formed due to wave action. A surficial layer of rock was observed on the slope, but it provided little or no protection. The portion of the slope above the normal water surface is adequately protected against surface runoff by an unmaintained vegetative cover ranging from tall grass to small bushes (see Photo 1). No trees were observed on the upstream slope; however, several small saplings were growing on the slope. The steepness of the upstream slope above the normal water surface level did not appear to be indicative of the slope angle for the remaining portion of the slope. Nevertheless, the combination of the steepness of the slope

and the vegetative cover hampered a comprehensive inspection of the slope. No bulges, depressions or cracks indicating an instability of the embankment or foundation were apparent.

The downstream slope is protected by an unmaintained dense, vegetative cover ranging from tall grass to brush (see Photo 3). The vegetative cover hampered a comprehensive inspection of the slope. A few large trees were also observed on the slope near the left abutment. No bulges, depressions, or cracks indicative of a major slope movement were observed.

Three areas of possible seepage were observed along the downstream slope of the dam. The largest of the three areas was observed at approximately 215 feet to left of the right abutment and extended from near the toe of the dam to about one-third the way up the slope. The area is approximately 60 feet long and is characterized by moist, boggy ground and cattails (see Photo 4). This entire area is contained within a shallow depression. A scarp less than one foot deep was observed at the top of the depression. The sloughing in this area did not appear to be due to a recent instability of the slope. The source of the moisture in this area is unknown; however, due to the location of the area, it is most likely due to seepage through the embankment. The seepage could cause the embankment material to be weakened, which could have caused the observed partial failure of the slope. No measurable flow of water was observed; however, the cattails would indicate that moisture is generally present in the area.

Another area of possible seepage was observed on the downstream slope about 120 feet from the right abutment, and approximately one-third the way up the embankment from the toe. The area is similar to the area described above but on a much smaller scale. The area is only 15 feet long. Cattails, moist boggy ground and a few small shallow scarps were observed in the area. The sloughing in this area did not appear to be due to any recent movements of the slope. It was undetermined whether the source of the moisture in

the area was due to seepage through the embankment; however, due to location and size of the area, this condition most likely is due to seepage. No measurable flow of water was observed.

The third area of possible seepage was observed just downstream of the toe of the dam and directly below the second area of possible seepage described above. This area was characterized by standing water and cattails (see Photo 5). It was unknown whether the source of the water was due to recent rainstorms in the area or due to seepage through the embankment or foundation. Nevertheless, the cattails in the area would indicate that moisture is generally present. No measurable flow of water was observed.

A small embankment pond was observed just downstream of the toe of the dam (see Photos 4 and 14). The source of the water in the pond does not appear to be due to seepage through or under the dam embankment, since the discharge channel of the spillway leads directly into the pond.

The right abutment slopes gently upward from the dam. No erosion felt to be detrimental to the safety of the dam or abutment was apparent. The left abutment is at approximately the same elevation as the top of the dam. The only problem observed on the left abutment, which could be detrimental to the dam and abutment, is the severe erosion in the spillway discharge channel, as described in Section 3.1d. No instabilities were observed on either abutment.

According to Mr. Shy, there has been some muskrat activity in the reservoir in the past; however, the muskrats are annually trapped. No evidence of burrowing animals was apparent on either the embankment or the abutments.

c. Project Geology and Soils

(1) Project Geology

The damsite is located on an unnamed tributary of Joachim Creek in the Salem Plateau section of the Ozark Plateaus Physiographic Province. Deep dissection of topography by major streams is one of the important characteristics of the Salem Plateau section. There is a wide distribution of dolomites and limestones in the Salem Plateau. Cuestaform topography is exhibited in this plateau section consisting of two major escarpments, namely the Crystal Escarpment and Burlington Escarpment. Deep dissection in dolomites and limestones is a major factor in the development of many springs in this area. A major component of surface discharge of water to the regional drainage is contributed by these springs.

The topography in the vicinity of the damsite is hilly with V-shaped valleys. Elevations of the ground surface range from 1020.0 feet above M.S.L. nearly 1.9 miles south of the damsite to 710.0 feet above M.S.L. at the damsite. The reservoir slopes are generally from ten to 18 degrees from horizontal and appear to be stable. The area near the damsite is covered with residual soil deposits consisting of a reddish-brown and orangey-brown mottled, moderately plastic, silty clay with some fine sand and occasional rock fragments less than 1/4 inch in size.

The regional bedrock geology beneath the residual soil deposits in the damsite area as shown on the Geologic Map of Missouri (1979) (see Plate 6) are of the Ordovician age rocks consisting of Decorah Formation, St. Peter Sandstone, Powell Dolomite, Cotter Dolomite, Roubidoux Formation, and Gasconade Dolomite; and the Cambrian age rocks consisting of Eminence Dolomite, Potosi Dolomite, Lamotte Sandstone, and Franconia and Bonneterre Formations. The predominent bedrock underlying the residual soil deposits in the vicinity of the damsite are the Ordovician age rocks consisting of Powell Dolomite and Roubidoux Formation.

Outcroppings of Ordovician Powell Dolomite (light brownish-gray, fine grained, very hard, generally massive, slightly weathered dolomite) are exposed in the discharge channel of the spillway (see Photos 10 and 12). Moderate solution activity and secondary sedimentary internal structures (such as spherulites and concretions) were observed in the rock outcroppings.

No active faults have been identified at the damsite. The closest trace of a fault to the damsite is the Ste. Genevieve fault system. The Ste. Genevieve fault had its last movement in the post-Pennsylvanian time and, thus, should have no effect on the damsite.

No boring logs or construction reports are available that would indicate foundation conditions encountered during construction. Based on the visual inspection and conversations with Mr. Shy, the embankment probably rests on the bedrock of the Ordovician Powell Dolomite with the core trench excavated to the bedrock. The spillway rests on a thin layer of residual soils, which overlays the Powell Dolomite bedrock.

(2) Project Soils

According to the "Missouri General Soil Map and Soil Association Description" published by the Soil Conservation Service, the materials in the general area of the dam belong to the soil series of Union-Goss-Gasconade-Peridge in the Ozark Border Association. The soils are basically formed from loess deposits and weathered bedrock. These soils vary from a slowly permeable silty clay to moderately permeable silt loam.

Material removed from the embankment slopes was a reddish-brown, moderately plastic, silty clay with traces of fine to medium sand. Based upon the Unified Soil Classification System, the soil would be classified as a CL. This is an impervious soil type, which generally has the following characteristics: a coefficient of

permeability less than one foot per year, medium shear strength, and a high resistance to piping. This soil type also has a high resistance to erosion under low velocity flow; however, excessive erosion can occur during the high velocity flows that can be expected when the dam is overtopped.

d. Appurtenant Structures

(1) Spillway

An addition was made to the concrete weir, one or two years ago, increasing the thickness from eight inches to the existing 1.8 to 2.3 feet thickness. As described in Section 1.2g, the purpose of the addition was to extend the cutoff wall further below the spillway slab in order to stop seepage under the slab. The new cutoff wall did not stop the seepage, but did reduce the flow, according to Mr. Sells. Water was observed flowing between the spillway slab/natural ground interface at the outfall of the spillway channel. The flow rate was estimated to be less than five gallons per minute. The discharge was clear and no undermining along the length of the spillway slab due to the seepage was evident. The placement of the addition was done in an unprofessional mannner evidenced by the variable thickness of the resultant structure (see Photo 6). Although the newer concrete appeared undamaged and sound, water was flowing through cracks in the weir near the channel invert at the centerline of the spillway (see Photo 6).

The concrete of the spillway channel has numerous cracks particularly in the area where vehicles cross the spillway (see Photo 7). Patches of lighter colored concrete were evident in this area indicating some repair work has been done to the spillway channel. Downstream of this area, the surface of the concrete appeared sound with no noticeable sign of weathering. This stable condition ends at the spillway outfall where a roughly triangular shaped piece of concrete, eight feet at the base and extending five feet back into the spillway, has broken off and fallen into the

discharge channel (see Photos 8 and 9). The cause of the failure was due to the undermining of the spillway outfall coupled with the lack of reinforcement in the slab as no reinforcement was evident at the fracture point (see Photo 9). The remaining width of the spillway outfall is currently undermined about five feet and failure of this portion is imminent. The slab is four to five inches thick at the outfall.

The discharge channel is severely eroded at the spillway outfall. The channel side slopes vary from negative to near vertical and are unprotected. Debris (tree stumps, branches, and leaves) have been dumped into the discharge channel (see Photo 8). The invert of the discharge channel is stable where bedrock has been reached, approximately 15 feet below the elevation of the spillway outfall (see Photo 10).

(2) Outlet Works

No low-level outlet or outlet works were provided for this dam.

e. Reservoir Area

The reservoir water surface elevation at the time of the inspection was 709.8 feet above M.S.L. The reservoir has a normal water surface elevation of 710.0 feet above M.S.L. and a surface area of 13 acres at the normal water surface level.

The rim appeared to be stable with no erosional or stability problems observed (see Photo 13). The land around the reservoir slopes gently to moderately upward from the reservoir rim and is mostly wooded with grass-covered slopes. Several houses are built around the reservoir rim. No evidence of excessive siltation was observed in the reservoir on the day of the inspection.

Three dams and reservoirs are located upstream of Clear Lake and were considered to be large enough to have an effect on the flood routing evaluation for Clear Lake Dam, as further discussed in Section 5 (see Plate 2). The three dams are named as follows: Sunrise Lake Dam (Mo. 31190); Big Lake Dam (Mo. 30457); and Little Lake Dam (Mo. 30456). Sunrise Lake Dam is located at the upper reach of the Clear Lake (see Photo 13).

f. Downstream Channel

The downstream channel near the dam is the natural streambed, which was narrow and obstructed with trees and brush. Outside of the streambed, the downstream channel widens into a fairly wide flood plain (see Photo 14).

3.2 Evaluation

The following conditions were noted during the visual inspection, which warrant prompt attention.

1. The three areas of possible seepage observed along the downstream slope could have a detrimental effect on the structural stability of the dam. If the moisture in these areas is indeed due to seepage through the embankment, it is possible that the rate of seepage could increase with time and transport soil particles. This could cause piping of embankment material, which could lead to the eventual failure of the embankment. The depression and scarps observed on the slope indicate that the embankment in these areas may have been weakened by the possible seepage.

2. The undermining of the spillway outfall presents a real and imminent threat to the stability and safety of the spillway. A portion of the spillway has already collapsed and future flows through the spillway will aggravate the progressive nature of

the erosion, which will spell the eventual failure of the remaining spillway channel.

The following conditions were observed that could adversely affect the dam in the future and will require maintenance within a reasonable period of time.

1. The leakage through the spillway system will only hasten the demise of the spillway channel. It appears that flow is following the spillway slab/natural ground interface and exiting at the top of the vertical face of the undermined area of the spillway outfall, which could be contributing to the erosion there.

2. The cracks in the spillway channel did not appear to indicate an unsafe condition; however, the cracks do provide an avenue by which water can flow under the spillway slab. Water flowing under the spillway slab could undermine it, resulting in an unsafe condition.

3. The erosion in the discharge channel of the spillway jeopardizes the structural stability of the channel. The debris dumped in the discharge channel also contributes to the instability of the channel, by creating turbulence which increases the erosive capability of flows in the channel.

4. The erosion due to wave action on the upstream slope does not appear to affect the stability of the dam in its present condition. However, continual erosion of the slope can only be detrimental to the structural integrity of the dam.

5. The unmaintained vegetative cover on the embankment slopes and the trees on the downstream slope pose a potential danger to the safety of the dam. Depending upon the extent of the root system, the roots of large trees present possible paths for

piping through the embankment. The root systems can also do damage to the embankment from being uprooted by a storm. And, a heavy unmaintined growth of vegetation on the embankment hinders a comprehensive inspection of the dam, which could allow potential problems to go undetected.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Clear Lake Dam is used to impound water for recreational use as a private lake. There are no specific procedures that are followed for the operation of the dam. The water level in the reservoir is allowed to remain as high as possible. The water surface elevation is controlled by rainfall, runoff, evaporation, seepage and the crest elevation of the spillway weir.

4.2 Maintenance of Dam

The maintenance of the dam appears to be inadequate. The embankment slopes are covered with an unmaintained vegetative growth ranging from tall grass to small bushes and a few trees are growing on the downstream slope. According to Mr. Sells, the Property Owners Association has recently removed some of the trees from the dam embankment and that the association also mows the grass on the embankment. No riprap protection is provided on the upstream slope of the dam.

An attempt was made to stop the seepage under the spillway slab; however, the attempt was futile. Deterioration of the spillway system was observed, as evidenced by the undermining of the spillway slab at the outfall, the partial failure of the slab due to the undermining, the uncontrolled cracking of the spillway slab, and the erosion in the discharge channel. Some repair work to the spillway slab was observed.

4.3 Maintenance of Operating Facilities

There are no operating facilities associated with this dam.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any warning system in use at the damsite, such as an electrical warning system or a manual notification plan.

4.5 Evaluation

The maintenance at Clear Lake Dam appears to be inadequate; however, the dam does not appear to be neglected. It is recommended that the remedial measures described in Section 7 should be undertaken within a reasonable period of time to improve the condition of the dam.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

No hydrologic and hydraulic design data are available for Clear Lake Dam. The sizes of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were prepared from field notes and sketches prepared during the field inspection. The reservoir elevation-area data were based on the U.S.G.S. Vineland, Missouri Quadrangle topographic map (Advance Print, 7.5 minute series). The spillway and overtop release rates and the reservoir elevation-area data are presented in Appendix B.

The hydrologic soil group of the watershed was determined from information available in the U.S.D.A. Soil Conservation Service publication "Missouri General Soil Map and Soil Association Descriptions", 1979. The Probable Maximum Precipitation (PMP) used to determine the Probable Maximum Flood (PMF) was determined by using the U.S. Weather Bureau publication "Hydrometeorological Report No. 33" (April 1956). The 100-year and the 10-year floods were derived from the 100-year and the 10-year rainfalls, respectively, of Ste. Genevieve, Missouri.

b. Experience Data

Records of reservoir stage or spillway discharge are not maintained for this site. However, according to Mr. Shy, the maximum reservoir level was approximately 18 inches above the crest of the spillway.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

Both the Probable Maximum Flood and one-half of the Probable Maximum Flood, which is considered to be the appropriate spillway design flood for this dam, when routed through the reservoir, resulted in overtopping of the dam. The peak inflows of the PMF and one-half of the PMF are 12,820 cfs and 5,106 cfs, respectively. The peak outflow discharges for the PMF and one-half of the PMF are 12,721 cfs and 4,893 cfs, respectively. The maximum capacity of the spillway just before overtopping the dam is 1,954 cfs. The PMF overtopped the dam by 4.00 feet and one-half of the PMF overtopped the dam by 1.95 feet. The total duration of flow over the dam is 5.6 hours during the occurrence of the PMF and 3.1 hours during one-half of the PMF. The spillway/reservoir system of Clear Lake Dam is capable of accommodating a flood equal to approximately 20 percent of the PMF just before overtopping the dam and will also accommodate the one-percent chance flood (100-year flood) without overtopping the dam. The analysis of Clear Lake Dam included the hypothetical breach of the three upstream dams (Sunrise Lake Dam (Mo. 31190), Big Lake Dam (Mo. 30457), and Little Lake Dam (Mo. 30456)) for those floods during which the dams were overtopped.

The surface soils on the embankment consists of a silty clay. The top of dam supports a gravel road and the downstream slope has a good cover of grass. However, the dam will be overtopped by approximately two feet during the occurrence of one-half of the PMF, which can cause severe erosion to the embankment due to the high velocity of flow on its downstream slope and could lead to the eventual failure of the dam. The concrete lining of the spillway channel should resist excessive erosion during the occurrence of

one-half the PMF; however, the high velocity flows will cause further undermining of the spillway channel outfall and further erosion in the spillway discharge channel.

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends approximately two miles downstream of the dam. Located within the damage zone are at least three dwellings, one building, and a county highway (Highway V), which parallels Joachim Creek.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment or foundation during the visual inspection, except for the scarps and the shallow depressions observed in the areas of the possible seepage. The three areas of possible seepage observed along the downstream slope could be detrimental to the stability of the embankment. The wave erosion on the upstream slope does not appear to endanger the structural stability of the embankment in its present condition; however, continual erosion of the slope could pose a potential hazard to the embankment. In the absence of seepage and stability analyses, no quantitative evaluation of the structural stability can be made.

The structural stability of the spillway is poor due to the undermining of the channel outfall, the leakage of water under the spillway slab and the lack of reinforcement in the spillway slab. The spillway is unobstructed and should be able to function properly, although flows through the channel will only hasten the destruction of the spillway. The structural stability of the eroded side slopes of the spillway discharge channel is also in jeopardy.

b. Design and Construction Data

No design computations pertaining to the embankment were uncovered during the report preparation phase. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters were available for carrying out a conventional stability analysis on the embankment. No

construction data or specifications relating to the degree of embankment compaction were available for use in a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam or the spillway. The water level on the day of inspection was 0.2 feet below the normal pool elevation.

d. Post Construction Changes

No post construction changes to the embankment are known to exist that will affect the structural stability of the dam. The only known modification at the damsite was the extension of the cutoff wall of the spillway made one to two years ago. This modification was made to stop the seepage under the spillway slab; however, the attempt was futile.

e. Seismic Stability

The dam is located in Seismic Zone 2, as defined in the "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers (see Plate 9). Seismic Zone 2 is characterized by a moderate earthquake hazard. An earthquake of the magnitude that would be expected in Seismic Zone 2 should not cause significant distress to a well designed and constructed earth dam. Available literature indicates that no active faults exist near the vicinity of the damsite. The maximum recorded historic magnitude earthquake in the immediate vicinity of the damsite was the July 21, 1967 event of magnitude 4.4 located at a distance of approximately 36 miles southeast of the damsite. This event cannot be correlated with known tectonic structure and is considered to probably be related to the release of accumulated residual strain along a buried pre-Quaternary fault. The attenuation of this event to the damsite

would produce a peak ground acceleration of less than 0.05g which would not produce a significant seismic impact on the dam.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and the visual inspection. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based upon observations of field conditions at the time of the inspection along with data available to the inspection team.

It is also important to realize that the condition of a dam depends upon numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be assurance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Clear Lake Dam is found to be "Seriously Inadequate". The spillway/reservoir system will accommodate about 20 percent of the PMF without overtopping the dam. If the dam is overtopped, the safety of the embankment would be in jeopardy due to the susceptibility of the embankment materials to erosion. High velocity flows on the downstream slope of the dam could cause excessive erosion and eventually lead to a failure of the dam. The spillway will also receive further damage during the occurrence of one-half of the PMF.

The overall condition of the dam appears to be fair; however, the areas of possible seepage could jeopardize the safety of the dam and do warrant prompt attention. A quantitative evaluation of the safety of the embankment could not be made in view of the absence of seepage and stability analyses. The present embankment, however, appears to have performed satisfactorily without failure since its construction. The dam has never been overtopped, according to Mr Shy, and no evidence indicating the contrary was observed. The safety of the dam can only be improved if the deficiencies described in Section 3.2 are properly corrected as described in Section 7.2b.

b. Adequacy of Information

The conclusions presented in this report are based upon field measurements, past performance and the present condition of the dam. Documented information on the design hydrology, hydraulic design, operation, and maintenance of the dam was not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency

The items recommended in paragraph 7.2a, regarding gaining additional spillway capacity, and the first two items in paragraph 7.2b, pertaining to the further investigation of the three areas of possible seepage and the repair of the undermining of the spillway slab, should be pursued on a high priority basis. The remaining remedial measures recommended in Paragraph 7.2b should be accomplished within a reasonable period of time.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

There are several options that may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Increase the spillway capacity to pass one-half of the PMF, without overtopping the dam. The spillway should also be adequately protected to prevent excessive erosion during the occurrence of one-half of the PMF.

2. Increase the height of the dam in order to pass one-half of the PMF without overtopping the dam; an investigation should also include studying the effects that increasing the height of the dam would have on the structural stability of the present embankment. The overtopping depth during the occurrence of one-half of the PMF, stated in Section 5.1d, is not the required or recommended increase in the height of the dam.

3. A combination of 1 and 2 above.

b. O & M Procedures

1. Further investigation of the three areas of possible seepage observed along the downstream slope should be undertaken to determine the seriousness of the condition. The investigation should be carried out under the direction of a qualified professional engineer and repairs made as required. The sloughing of the slope in these areas should also be monitored to detect any major slope movements.

2. The undermining of the spillway slab at the outfall should be repaired and the area protected from further damage. The spillway slab should also be repaired and stabilized.

3. The erosion in the discharge channel of the spillway should be repaired and the channel protected from further erosion. This should also include removing the debris from the channel.

4. The leakage of water under the spillway slab should be stopped.

5. The cracks in the spillway channel slab should be repaired.

6. The erosion due to wave action on the upstream slope should be properly repaired and the slope protected from further damage.

7. The trees and brush on the embankment slopes should be removed from the embankment and regrowth prevented. The grass cover on the embankment, especially on the downstream slope, should be periodically maintained. The grass cover should be retained on the downstream slope to protect it from erosion due to surface runoff and to prevent excessive erosion in the event the dam is overtopped. Removal of trees should be under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing could jeopardize the safety of the dam.

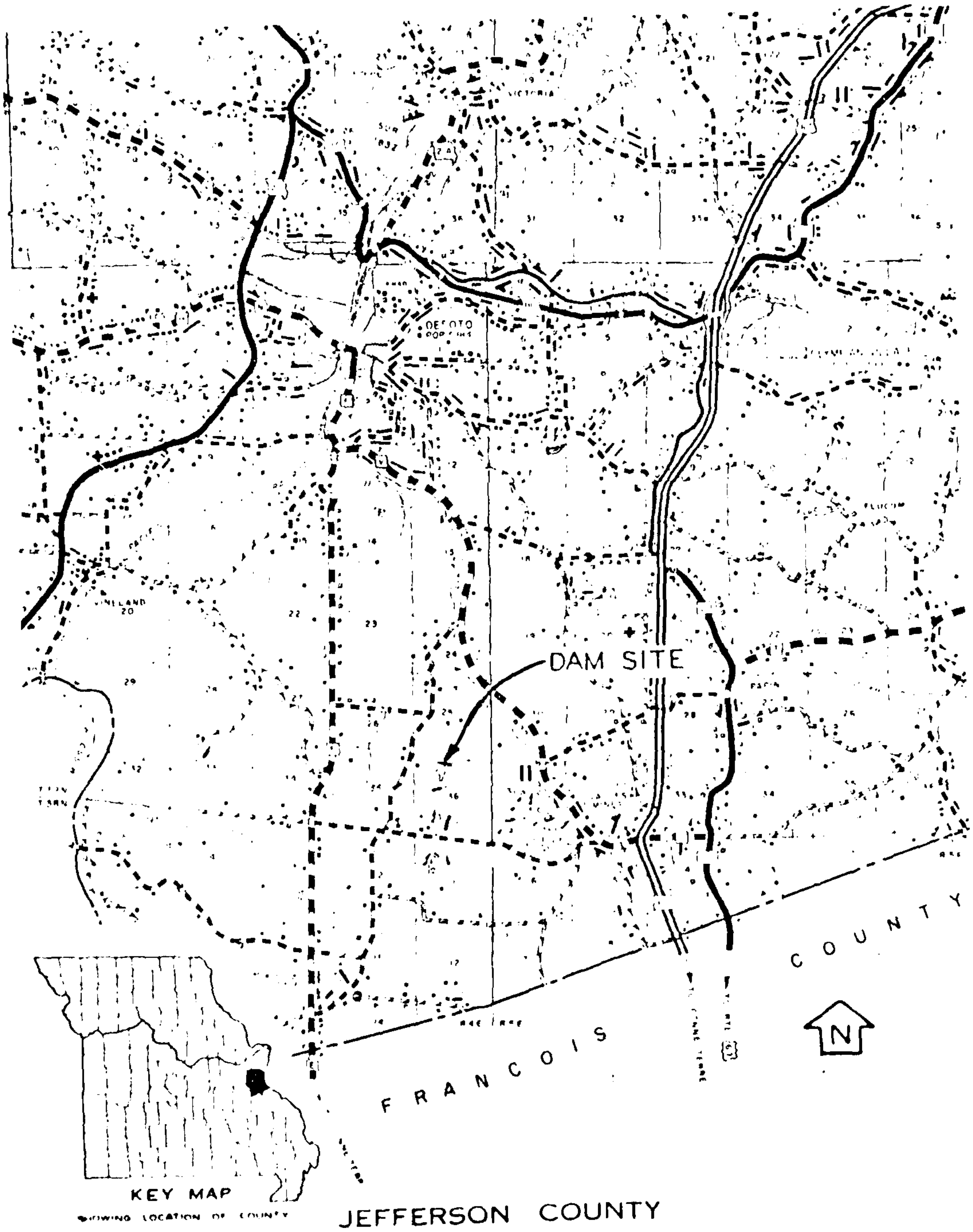
8. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.

9. The owner should initiate the following programs:

(a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earth dams.

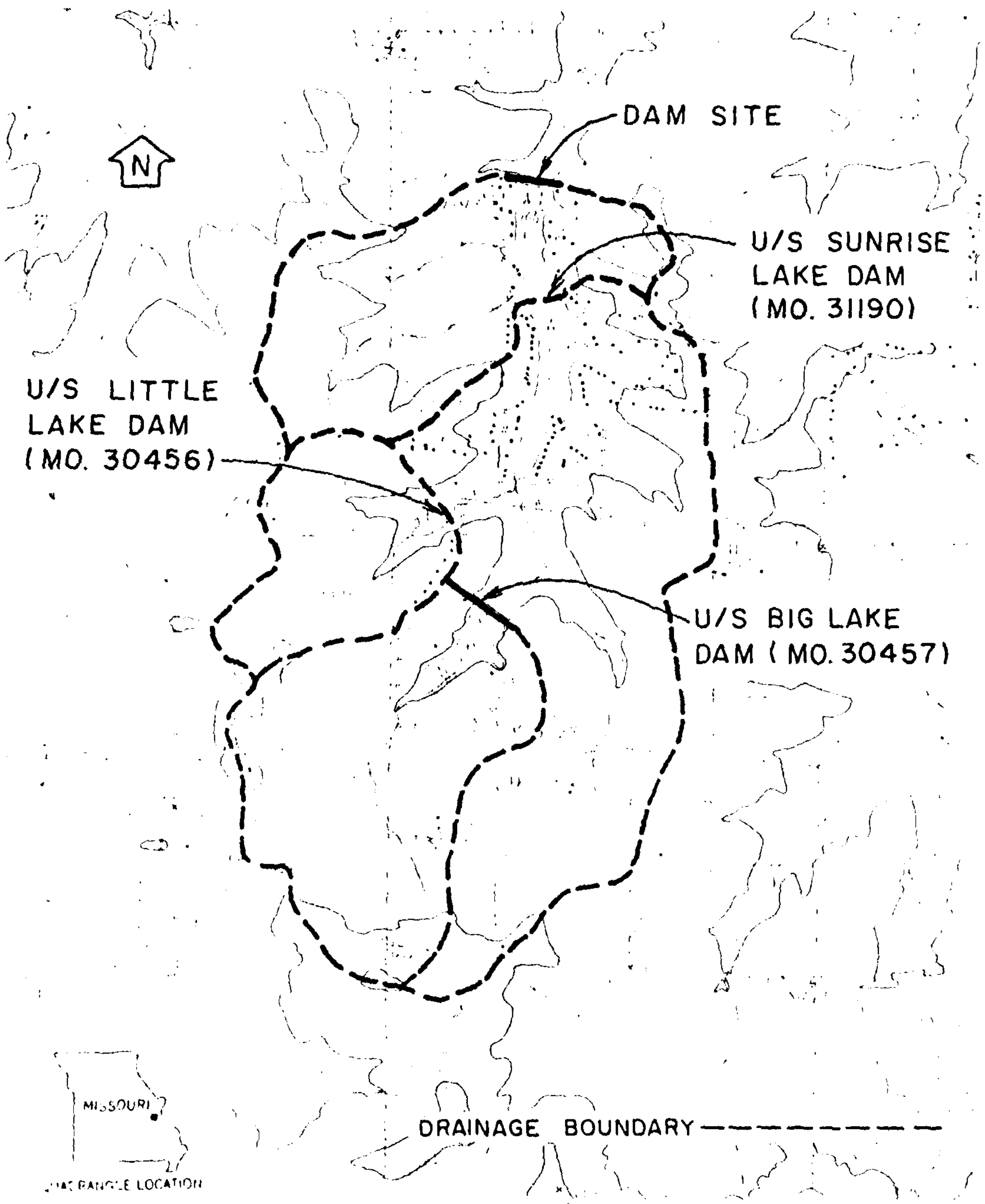
(b) Set up a maintenance schedule and log all repairs and maintenance.

PLATES



CLEAR LAKE DAM (MO. 30437)
LOCATION MAP

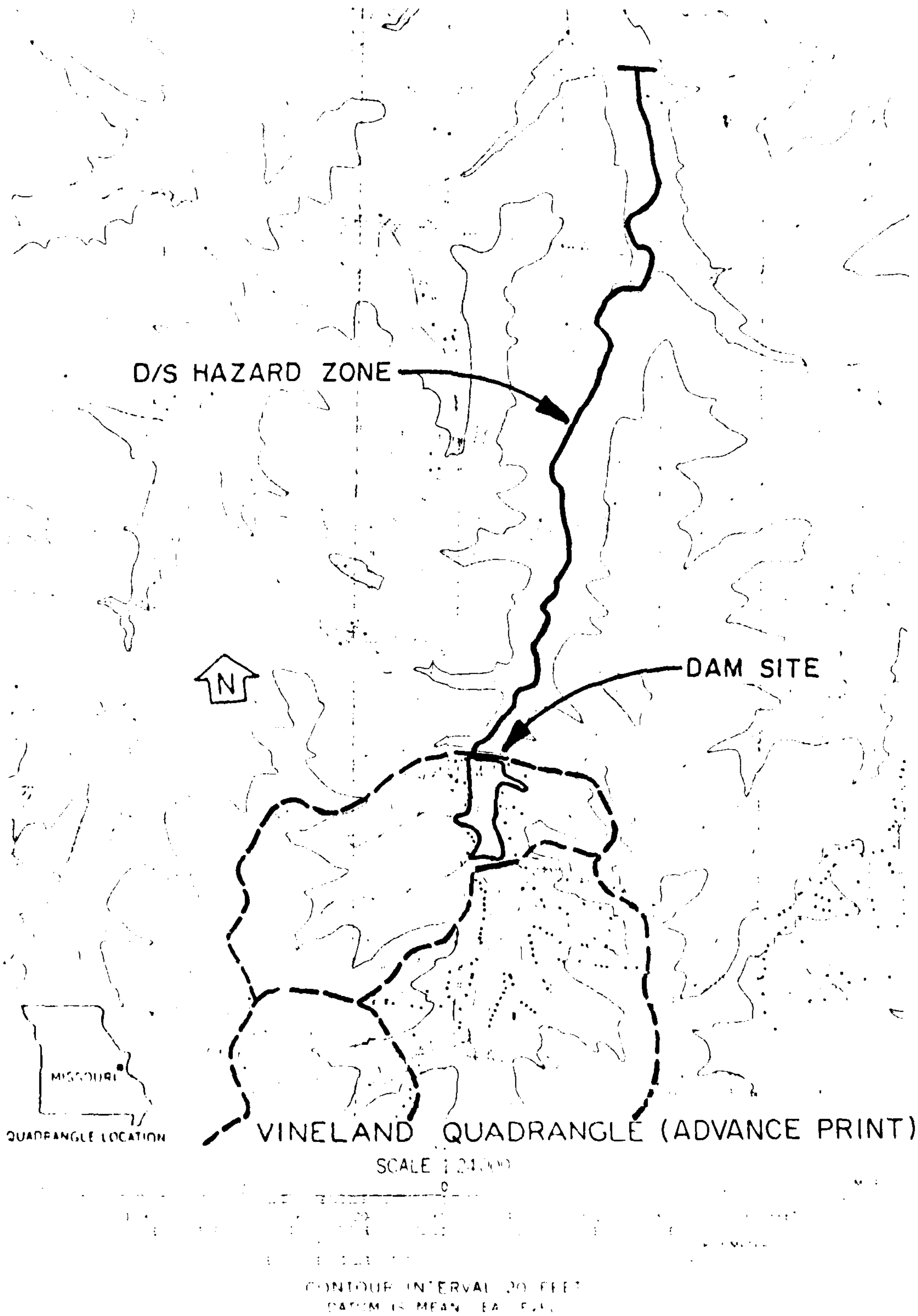
PLATE 2



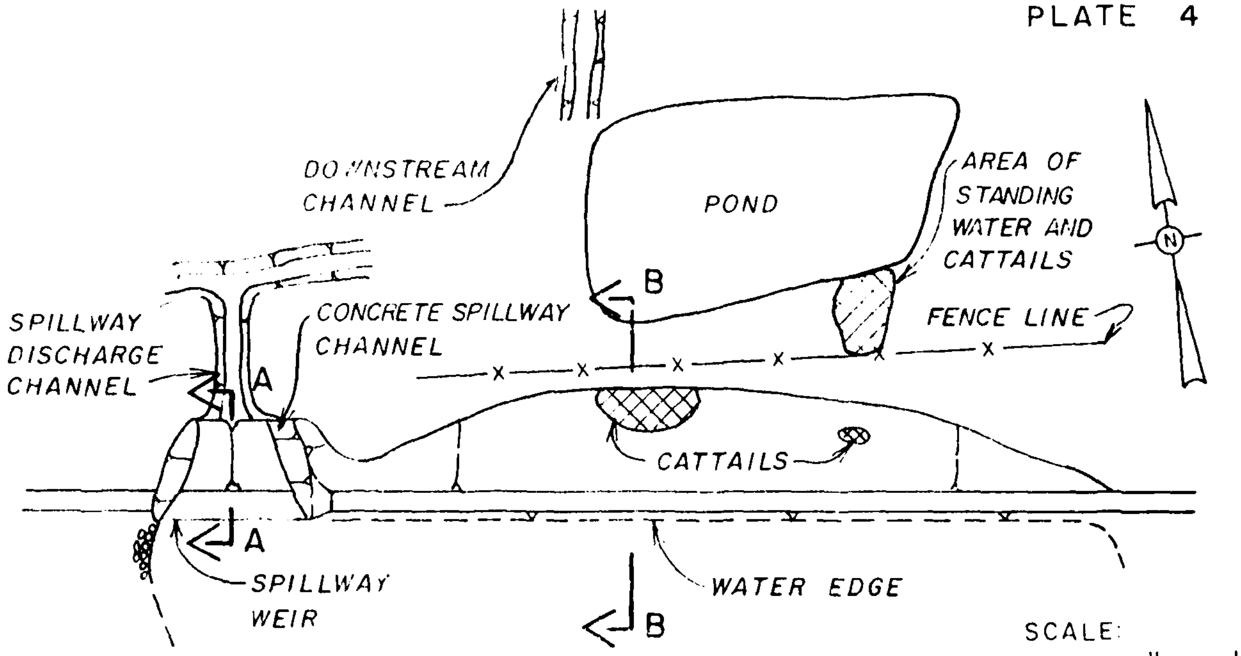
VINELAND QUADRANGLE (ADVANCE PRINT)

CLEAR LAKE DAM (MO. 30437)
DRAINAGE BASIN

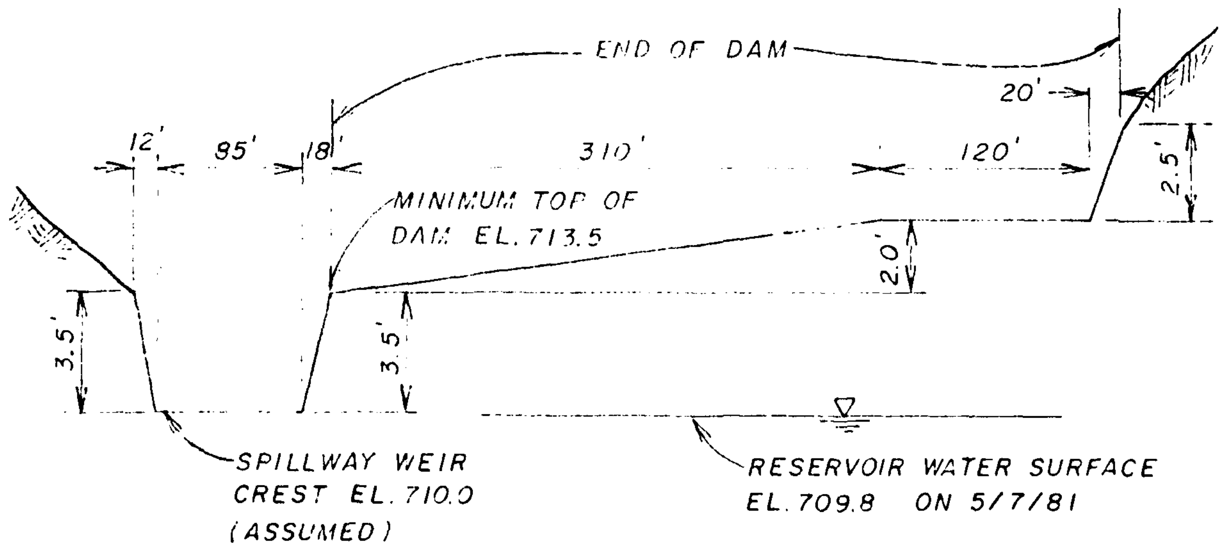
PLATE 3



CLEAR LAKE DAM (MO. 30437)
DOWNSTREAM HAZARD ZONE

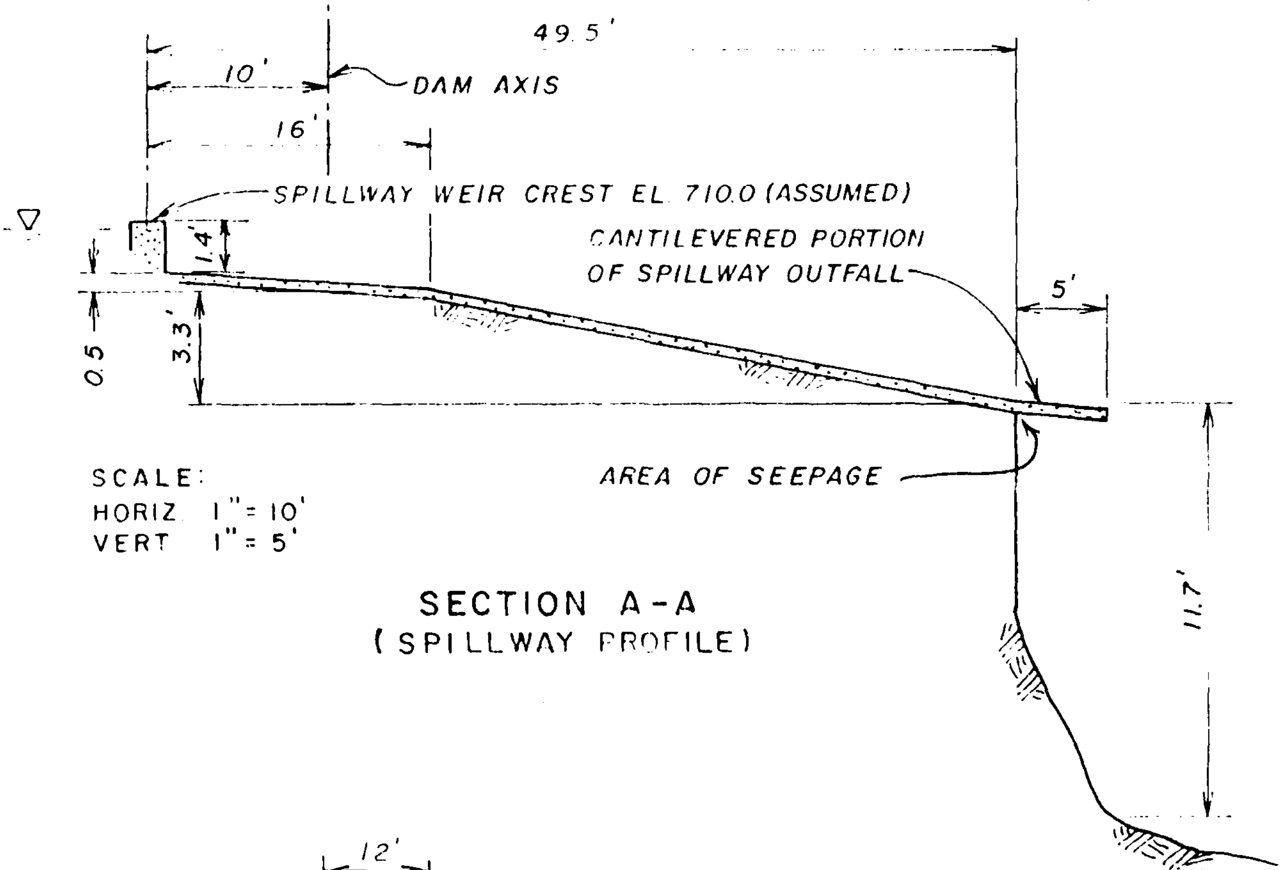


PLAN



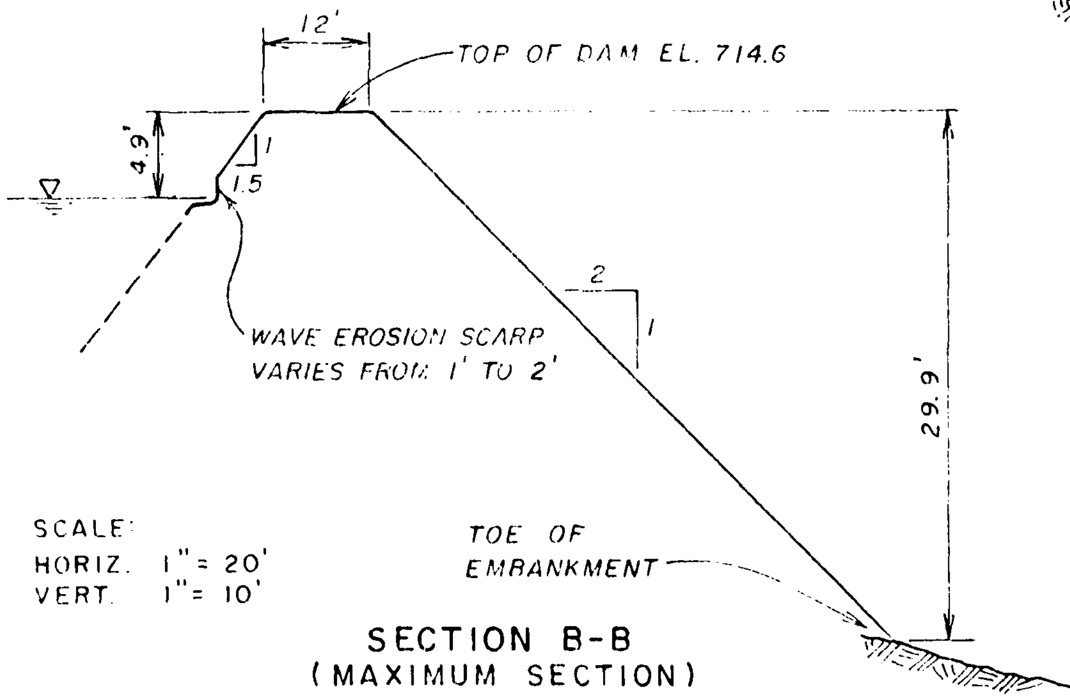
ELEVATION

CLEAR LAKE DAM (MO. 30437)
PLAN AND ELEVATION
(SHEET 1 OF 2)



SCALE:
HORIZ. 1" = 10'
VERT. 1" = 5'

SECTION A-A
(SPILLWAY PROFILE)

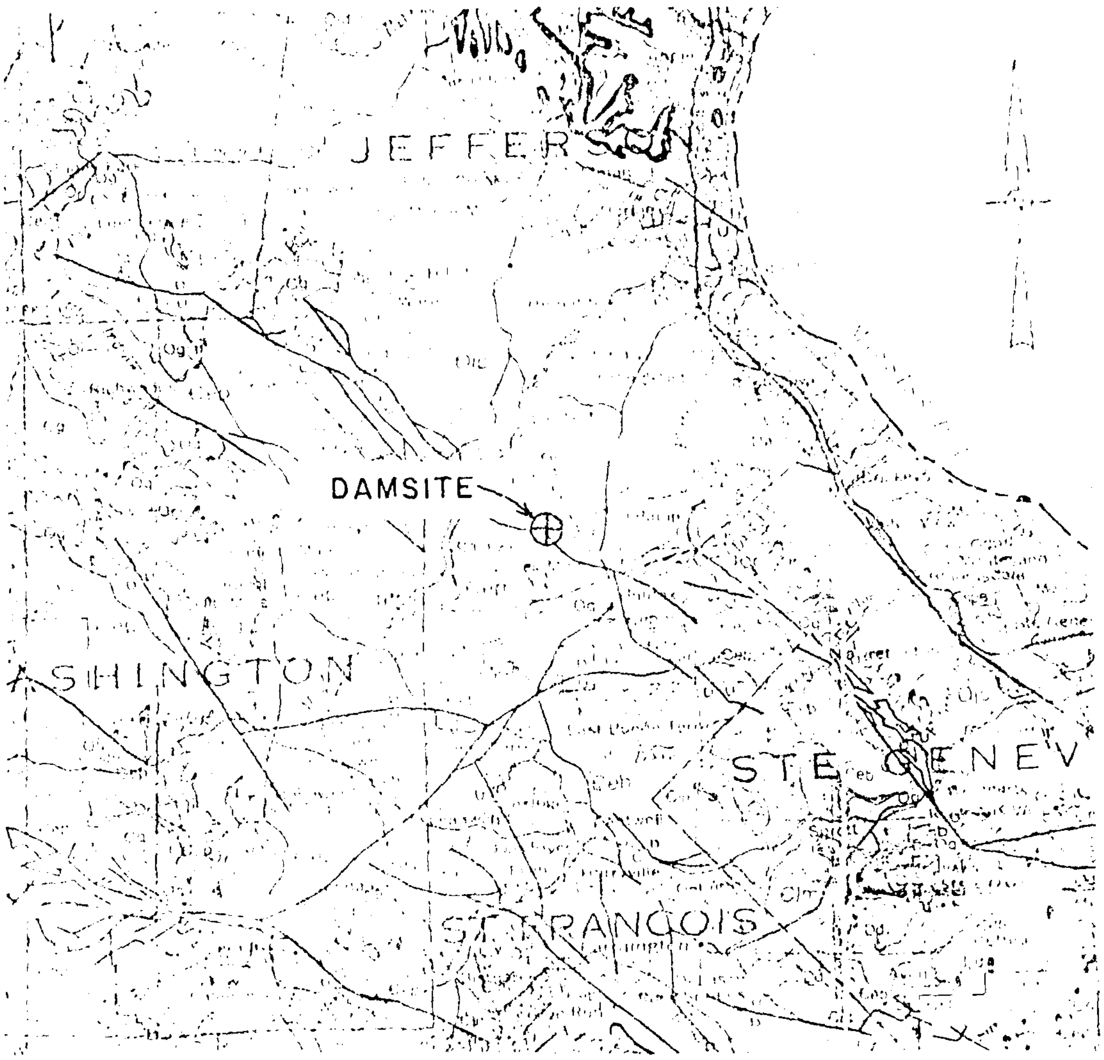


SCALE:
HORIZ. 1" = 20'
VERT. 1" = 10'

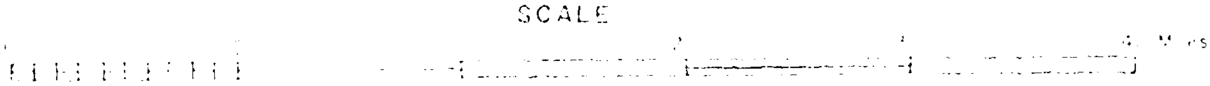
SECTION B-B
(MAXIMUM SECTION)

CLEAR LAKE DAM (MO. 30437)
SPILLWAY PROFILE AND MAXIMUM SECTION
(SHEET 2 OF 2)

PLATE 6



SCALE



LOCATION OF DAM

NOTE: LEGEND FOR THIS MAP IS ON PLATES 7 AND 8.

REFERENCE
GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H. ANDERSON, 1979

REGIONAL GEOLOGICAL MAP
OF
CLEAR LAKE DAM

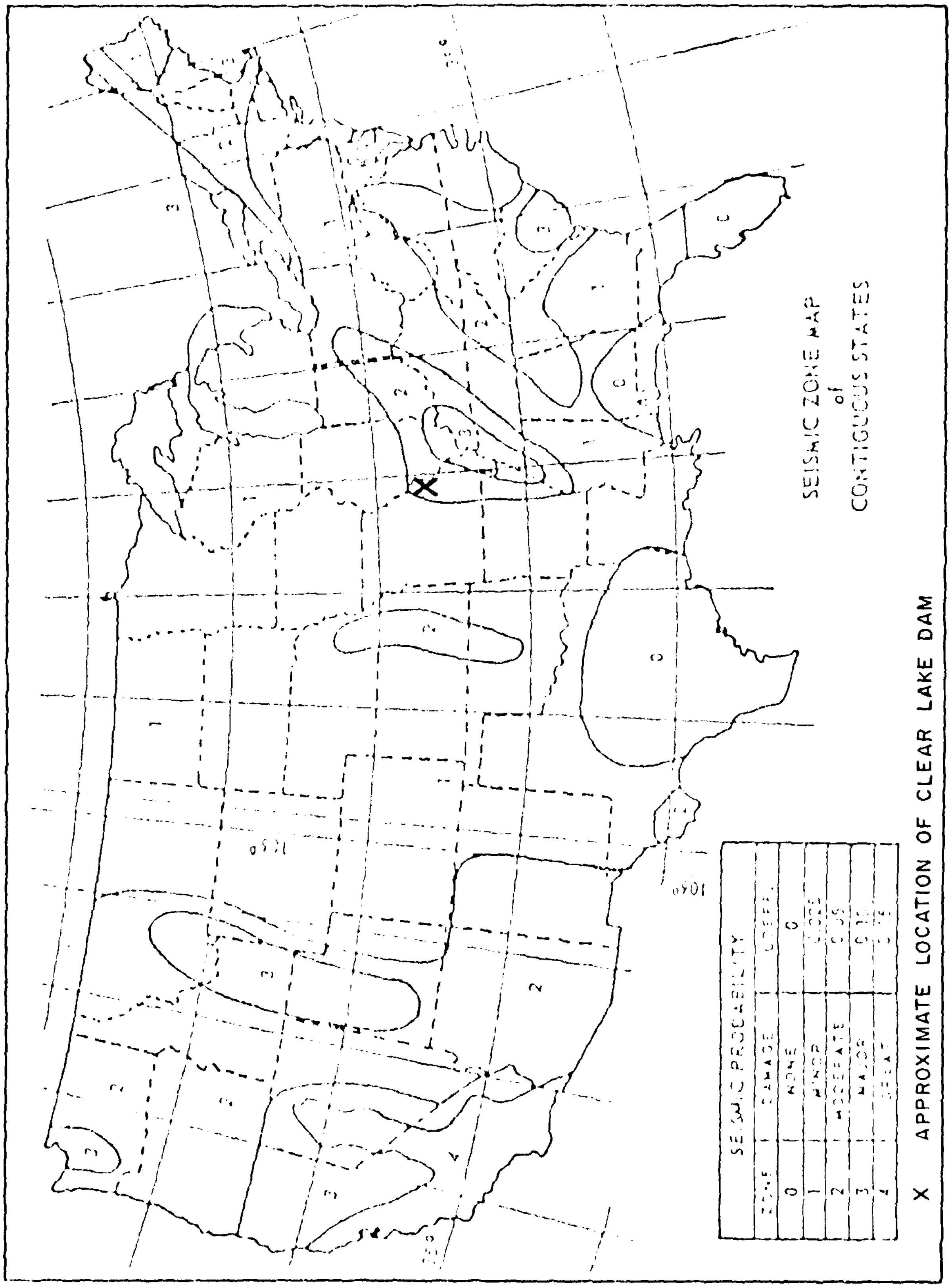
LEGEND

PERIOD	SYMBOL	DESCRIPTION
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
MISSISSIPPIAN	Mo	KEOKUK - BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	UNDIFFERENTIATED CHOUTEAU GROUP: LIMESTONE
	Mk	HANNIBAL FORMATION: SHALE AND SILTSTONE
DEVONIAN	Dd	DIATREMES, KIMBERLITES, CARBONATITES
ORDOVICIAN	Omk	MAQUOKETA SHALE, KIMMSWICK LIMESTONE
	Odp	DECORAH FORMATION: GREEN TO GRAY CALCAREOUS SHALE WITH THIN FOSSILIFEROUS LIMESTONE
	Ospe	ST. PETER SANDSTONE, EVERTON FORMATION
	Ojd	JOACHIM DOLOMITE
	Ojc	POWELL DOLOMITE, COTTER DOLOMITE
	Or	ROUBIDOUX FORMATION: INTERBEDS OF CHERTY LIMESTONE AND SANDSTONE
	Og	GASCONADE DOLOMITE

LEGEND

PERIOD	SYMBOL	DESCRIPTION
CAMBRIAN	€ep	EMINENCE DOLOMITE, POTOSI DOLOMITE
	€eb	FRANCONIA AND BONNETERRE FORMATION: INTERBEDDED LIMESTONE, CHERTY LIMESTONE, DOLOMITE AND SILTSTONE
	€lm	LAMOTTE SANDSTONE
PRECAMBRIAN	i	ST FRANCOIS MOUNTAINS INTRUSIVE
	v	ST FRANCOIS MOUNTAINS VOLCANIC
	U D	NORMAL FAULT
	U D	INFERRED FAULT
	U =	UPTHROWN SIDE; D = DOWNTHROWN SIDE

PLATE 9



SEISMIC ZONE MAP
of
CONTIGUOUS STATES
SEISMIC PROBABILITY
ZONE
DAMAGE
0
1
2
3
4
NONE
MINOR
MODERATE
MAJOR
GREAT
X APPROXIMATE LOCATION OF CLEAR LAKE DAM

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

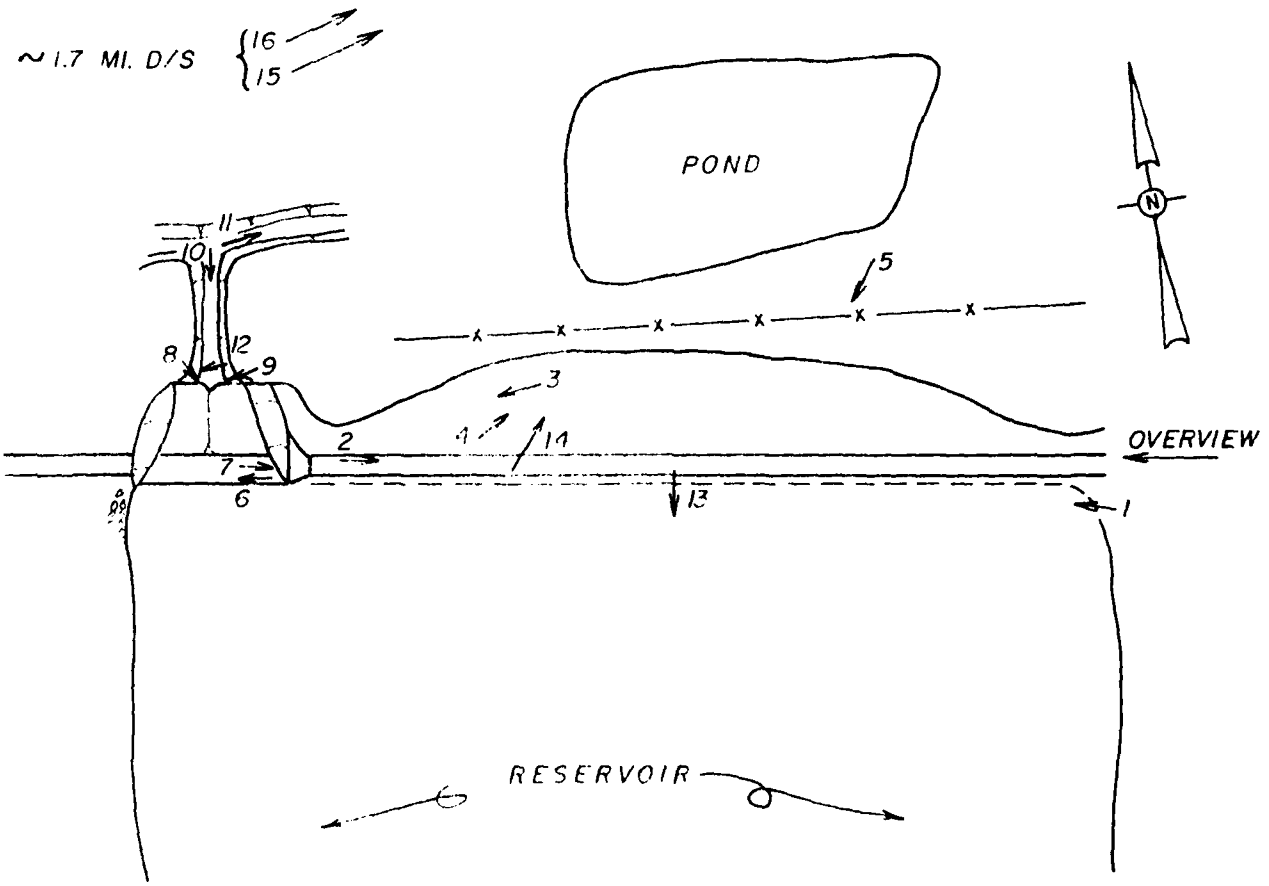


PHOTO INDEX
FOR
CLEAR LAKE DAM

Photo 1 - View of the upstream slope from the right abutment.

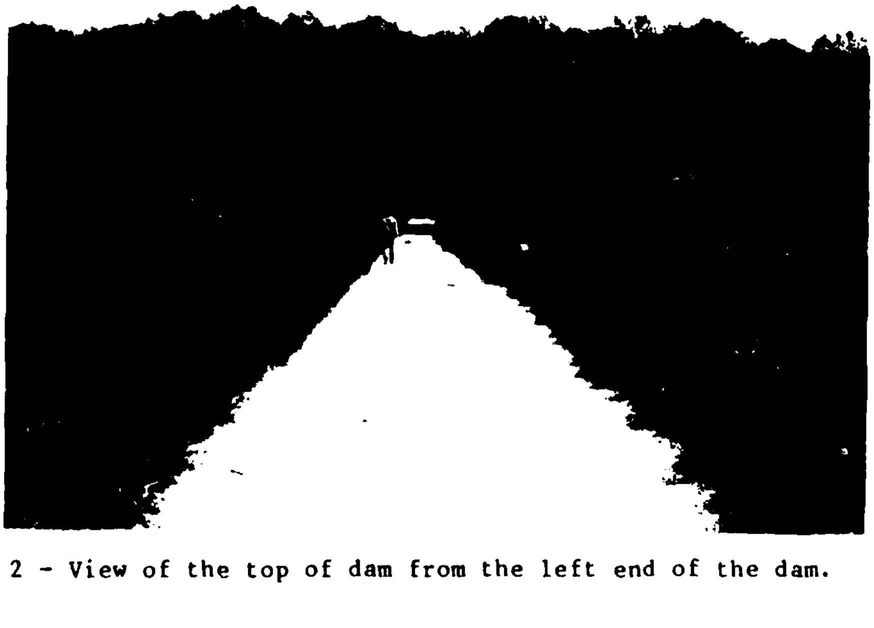


Photo 2 - View of the top of dam from the left end of the dam.

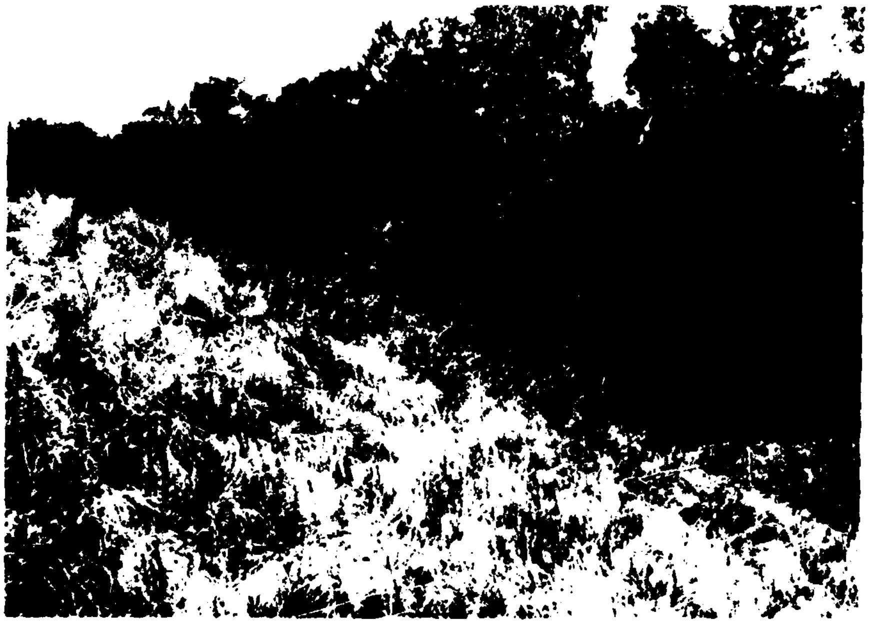


Photo 3 - View of the downstream slope looking towards the left abutment. The spillway discharge channel is behind the trees on the right.

Photo 4 - View of the downstream slope from near the top of dam showing an area of cattails and the pond downstream of the dam.

Photo 5 - Close-up view of standing water and cattails downstream of the toe of the dam.

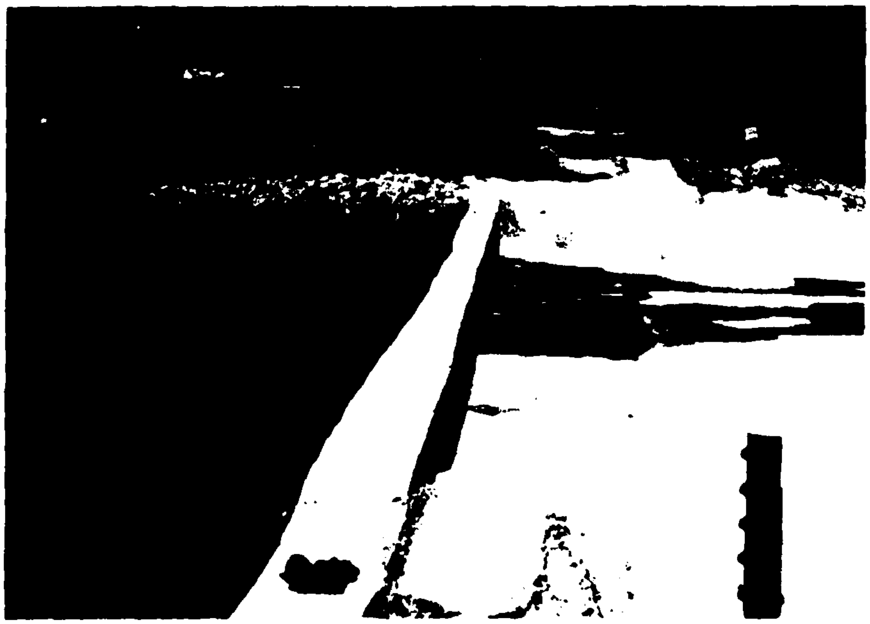


Photo 6 - View of the weir at the spillway control section and seepage into the spillway channel.

Photo 7 - Close-up view of the spillway channel showing cracking in the concrete slab.

Photo 8 - View of the spillway channel outfall showing the partial failure of the slab, the undermining of the slab, and the debris in the discharge channel. Note the spillway weir in the background.

Photo 9 - Close-up view of the spillway channel outfall showing the undermining and the partial failure of the slab.

Photo 10 - View of the spillway discharge channel looking upstream towards the spillway channel outfall. Note the spillway slab in the background at the top of the Photo and the outcropping of dolomite in the foreground.

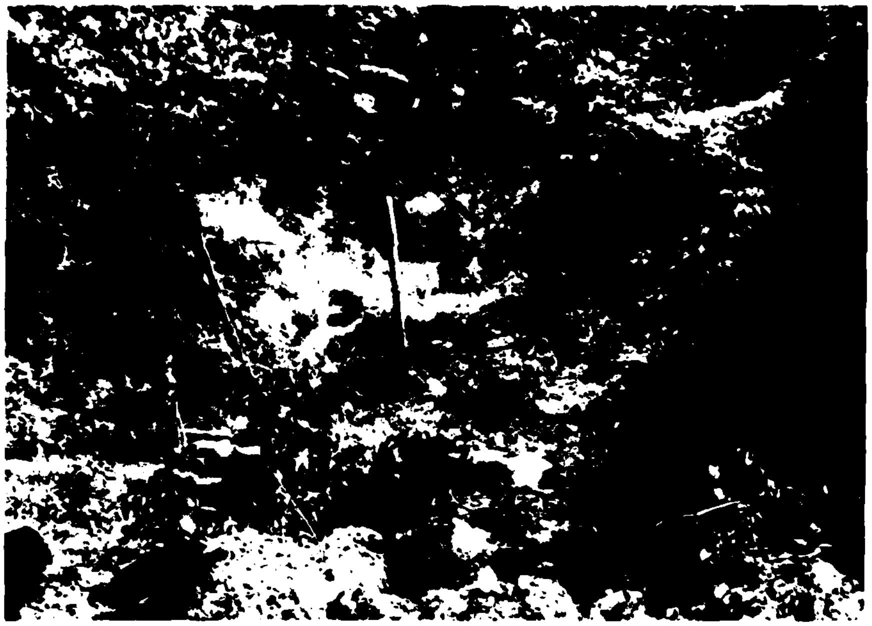


Photo 11 - View of the spillway discharge channel looking downstream.

Photo 12 - Close-up view of an outcropping of slightly weathered dolomite bedrock in the spillway discharge channel.

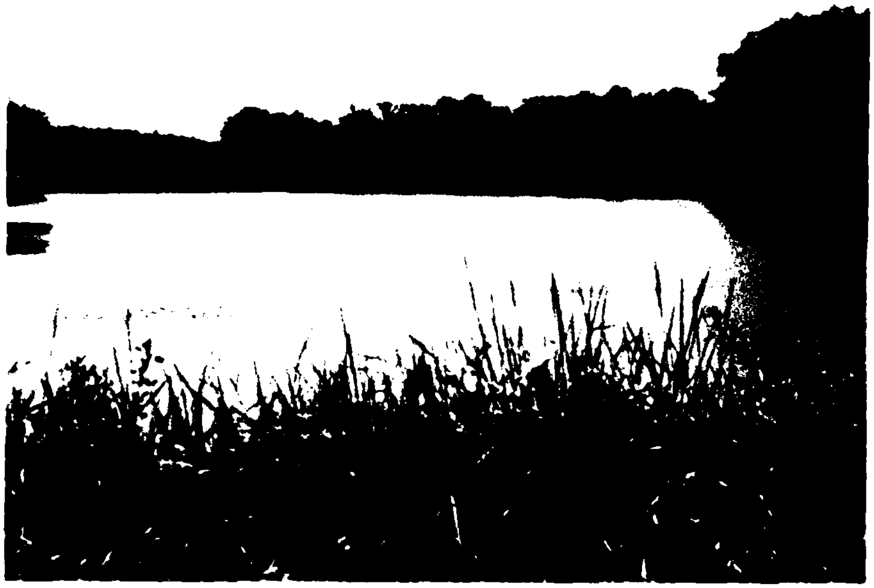


Photo 13 - View of the reservoir and rim. Note Sunrise Lake Dam in the background.

Photo 14 - View of the pond immediately downstream of the dam and the downstream channel.

Photo 15 - View of a dwelling in the downstream hazard zone looking across Joachim Creek.

Photo 16 - View of a dwelling in the downstream hazard zone looking across Joachim Creek.

APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

CLEAR LAKE DAM

HYDROLOGIC AND HYDRAULIC DATA, ASSUMPTIONS AND METHODOLOGY

1. SCS Unit Hydrograph procedures and the HEC-1DB computer program are used to develop the inflow hydrographs. The hydrologic inputs are as follows:

   (a) 24-hour Probable Maximum Precipitation from Hydrometeorological Report No. 33, and 24-hour 100-year rainfall and 24-hour 10-year rainfall of Ste. Genevieve, Missouri.

   (b) Drainage area = 1.65 square miles. (total drainage area)
   = 0.34 square miles. (excluding the drainage areas of the U/S dams)

   (c) Lag time = 0.14 hours (for Clear Lake subarea alone).

   (d) Hydrologic Soil Group:
   Soil Group "C".

   (e) Runoff curve number:
   CN = 73 for AMC II and CN = 87 for AMC III.

2. Flow rates through the spillway are based on assuming critical depth at the weir crest. Flow rates over the dam are based on the broad-crested weir equation $Q = CLH^{3/2}$ and critical depth assumption, in accordance with the procedures used in the HEC-1 computer program.

3. The spillway and the dam overtop rating curves are hand calculated and combined as shown on pages B-5 and B-6. This combined rating curve is input into HEC-1DB on the Y4 and Y5 cards. The $L and $V cards are, therefore, not used.

4. Floods are routed through Clear Lake to determine the capability of the spillway. The analysis of Clear Lake Dam included the hypothetical breach of the three upstream dams for those floods during which the respective dams were overtopped.

5. Critical assumptions concerning channel flow and breach parameters were made in accordance with the hydrologic and hydraulic guidelines provided by the St. Louis Corps of Engineers.

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION / MISSOURI — SHEET NO. 1 OF 1

DAM NAME: Clear Lake Dam (Mo. 30437) — JOB NO. 1283

UNIT HYDROGRAPH PARAMETERS — BY JFK — DATE 5/13/81

1) DRAINAGE AREA, $A = 0.34$ sq. mi = (217.5 acres)

2) LENGTH OF STREAM, $L = (1.7'' \times 2000' = 3400') = 0.64$ mi.

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$H_1 = 845$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 710$

5) ELEVATION OF CHANNEL BED AT 0.85L, $E_{85} = 810$

6) ELEVATION OF CHANNEL BED AT 0.10L, $E_{10} = 720$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10})/0.75L = 0.035$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$t_c = [(11.9 \times L^3)/(H_1 - H_2)]^{0.385} = [11.9 \times 0.64^3/(135)]^{0.385} = 0.24$ hr

B) BY VELOCITY ESTIMATE,

SLOPE = 3.5% $\Longrightarrow$ AVG. VELOCITY = 3

$t_c = L/V = 3400'/3 \text{ fps} \times \text{hr}/3600\text{s} = 0.31$

USE $t_c = 0.24$ hr

9) LAG TIME, $t_\ell = 0.6\, t_c = 0.14$

10) UNIT DURATION, $D \leq t_\ell/3 = 0.048$ < 0.083 hr.

USE $D = 0.083$ hr.

11) TIME TO PEAK, $T_p = D/2 + t_\ell = 0.18$ hr.

12) PEAK DISCHARGE,

$q_p = (484 \times A)/T_p = 484 \times 0.34/0.18 = 915$ cfs

ECI-4 PRC ENGINEERING CONSULTANTS, INC.

Dam Safety Inspection – Missouri SHEET NO. 1 OF 1
Clear Lake Dam (Mo. 30437) JOB NO. 1283
Reservoir Elevation - Area Data BY JFK DATE 5/14/81

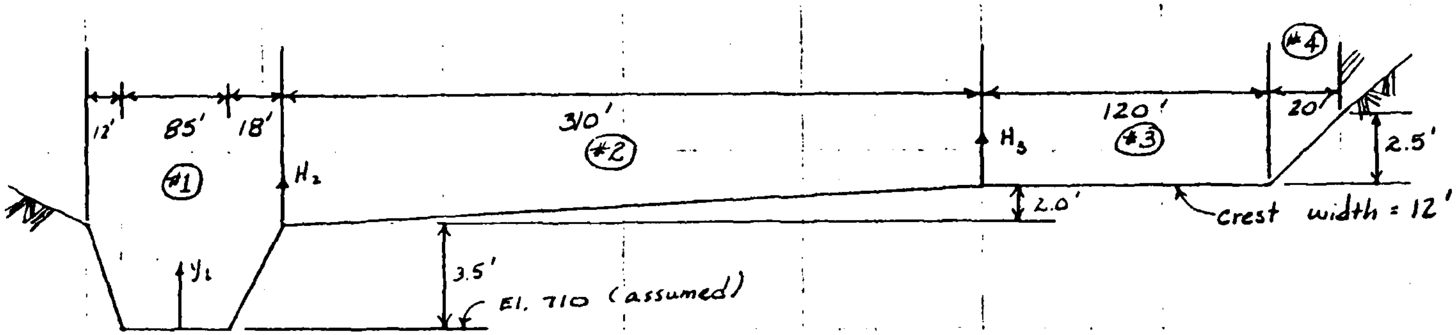
Elevation (ft, MSL)	Area	Remarks
685	0.0	Estimated Streambed U/S of dam
690	2.0	Interpolated
700	7.0	Interpolated
710	13.0	Spillway Crest (assumed)
713.5	15.0	Minimum Top of Dam
720	20.0	Measured from U.S.G.S. 7.5' Quad
730	27.5	Interpolated
740	35.5	Measured from U.S.G.S, 7.5' Quad

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

Dam Safety Inspection - Missouri — SHEET NO. 1 OF 3

Clear Lake Dam (Mo. 30437) — JOB NO. 1283

Spillway and Overtop Rating Curve — BY JFK DATE 5/14/81



Section #1*: $Q_1 = \sqrt{A_1^3 g / T_1}$; for $0 < y_1 \le 3.5$; for $3.5 < y_1$; $W.S.EL. = 710 + y_1 + V_1^2/2g$

$A_1 = 85.0 y_1 + 4.3 y_1^2$; $A_1 = 115.0 y_1 - 52.5$

$T_1 = 85.0 + 8.6 y_1$; $T_1 = 115.0$

Section #2*: $Q_2 = \sqrt{A_2^3 g / T_2}$; for $0 < y_2 \le 2.0$; for $2.0 < y_2$; $H_2 = W.S.EL. - 713.5$

$y_2 = 4/5\, H_2$; $y_2 = 2/3(H_2 + 0.5)$

$A_2 = 77.5\, y_2^2$; $A_2 = 310.0 y_2 - 310.0$

$T_2 = 155.0\, y_2$; $T_2 = 310.0$

Section #3 : $Q_3 = C L H_3^{1.5}$; $H_3 = W.S.EL. - 715.5$

Section #4*: $Q_4 = \sqrt{A_4^3 g / T_4}$; for $0 < y_4 \le 2.5$; for $2.5 < y_4$

$y_4 = 4/5\, H_3$; $y_4 = 2/3(H_3 + 0.6)$

$A_4 = 4.0 y_4^2$; $A_4 = 20.0 y_4 - 25.0$

$T_4 = 8.0 y_4$; $T_4 = 20.0$

* critical depth assumption

ECI-4 **PRC ENGINEERING CONSULTANTS, INC.**

Dam Safety Inspection - Missouri — SHEET NO. 2 OF 3

Clear Lake Dam (Mo. 30437) — JOB NO. 1283

Spillway and Overtop Rating Curve — BY JFK DATE 5/14/81

y_1	A_1	T_1	V_1	Q_1	W.S. EL.	H_2	Y_2	A_2	T_2	Q_2	H_3	C_3	Q_3	Y_4	A_4	T_4	Q_4	Q_{TOTAL}
0	0	0	0	0	710.0													0
0.3	25.9	87.6	3.1	79.9	710.5													80
0.5	43.6	89.3	4.0	172.7	710.7													173
0.8	70.7	91.9	5.0	352.3	711.2													352
1.0	89.3	93.6	5.5	494.9	711.5													495
1.3	117.7	96.1	6.3	739.4	711.9													739
1.5	137.1	97.9	6.7	921.3	712.2													921
1.8	166.9	100.4	7.3	1220.8	712.6													1221
2.0	187.1	102.1	7.7	1437.4	712.9													1437
2.3	218.2	104.7	8.2	1787.0	713.3	0	0	0	0	0								1787
2.5	239.3	106.4	8.5	2036.0	713.6	0.1	0.08	0.5	12.4	0.6								2037
2.8	271.6	109.0	9.0	2437.8	714.1	0.6	0.5	17.9	74.4	49.6								2482
3.0	293.6	110.7	9.2	2712.7	714.3	0.8	0.6	31.7	99.2	101.9								2815
3.3	327.2	113.3	9.6	3155.0	714.7	1.2	1.0	71.4	148.8	280.8								3436
3.5	350.0	115.0	9.9	3464.8	715.0	1.5	1.2	111.6	186.0	490.5								3955
3.8	384.5	115.0	10.4	3989.5	715.5	2.0	1.6	198.4	248.0	1007.0	0	0	0	0	0	0	0	4997
4.0	407.5	115.0	10.7	4352.8	715.8	2.3	1.8	262.4	285.2	1428.1	0.3	3.00	59.2	0.2	0.2	1.9	0.5	5841
4.5	465.0	115.0	11.4	5305.8	716.5	3.0	2.3	413.3	310.0	2708.3	0.7	3.03	213.0	0.6	1.3	4.5	3.8	8231
5.0	522.5	115.0	12.1	6319.9	717.3	3.8	2.9	578.7	310.0	4486.3	1.8	3.05	883.9	1.4	8.3	11.5	39.9	11730
5.5	580.0	115.0	12.7	7391.3	718.0	4.5	3.3	723.3	310.0	6269.8	2.5	3.08	1461.0	2.0	16.0	16.0	90.8	15213

Check critical depth assumption in spillway channel,

for $Q = 80$;

$y = 0.3$
$A = 25.9$
$P_w = 87.6$
$n = 0.015$

$$Q_c = \frac{1.49}{n} S_c^{1/2} R^{2/3} A$$

$$S_c = \left[\frac{Q_c n}{1.49} \frac{1}{R^{2/3}} \frac{1}{A}\right]^2$$

$$S_c = \left[\frac{80 \cdot 0.015}{1.49} \frac{1}{\left(\frac{25.9}{87.6}\right)^{2/3}} \frac{1}{25.9}\right]^2$$

$$S_c = 0.005$$

mildest slope in channel, $S = 0.5'/16' = 0.031$

$S_c < S_{channel}$

∴ Critical depth assumption is valid

SUMMARY OF PMF AND ONE-HALF PMF ROUTING

```
************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION   01 APR 80
************************************
    1              A1       DAM SAFETY INSPECTION - MISSOURI
    2              A2          CLEAR LAKE DAM (MO.30437)
    3              A3          PMF AND ONE-HALF PMF
    4              B     300       0       5       0       0       0       0       0       0       0
    5              B1      5
    6              J       1       2       1
    7              J1      1      .5
    8              K           BIGLK                                       1
    9              K1       RUNOFF CALCULATION FOR BIG LAKE DAM DRAINAGE AREA
   10              M       1       2     .42             .42       1                       1
   11              P              26     100     120     130
   12              T                                                      -1     -87
   13              W2            .14
   14              X                       1
   15              K       1   BIGLK                                       1
   16              K1       ROUTE HYDROGRAPH THROUGH BIG LAKE
   17              Y                               1       1
   18              Y1      1                                            -799      -1
   19              Y4    799   799.2   799.4   799.7   800.1   800.4   800.8   801.1   801.5   801.7
   20              Y4  802.1   802.4   802.8   803.0   803.4   803.7   804.1   804.4   805.1   805.9
   21              Y5      0       4      23      52     110     159     246     315     432     521
   22              Y5    670     780     964    1113    1464    1815    2451    3117    5119    7994
   23              $A      0     1.5     4.5      10    14.5    20.5      27    33.5
   24              $E    770     780     790     799     800   802.9     810     820
   25              $$    799
   26              $D  802.9
   27              $B     10      .5     784       1     799   802.9
   28              K       1   BIGLK                                       1
   29              K1       STREAM ROUTING OF HYDROGRAPH TO SUNRISE LAKE
   30              Y                               1       1
   31              Y1      1
   32              Y6    .08    .045     .08     740     800    2000    .002
   33              Y7      0     800     200     780     360     760     480     740     520     740
   34              Y7    600     760     640     780     840     800
```

B-9

```
35   K               LTTLLK                                         1
36   K1            RUNOFF CALCULATION FOR LITTLE LAKE DAM DRAINAGE AREA
37   M         1       2     .19             .19       1                             1
38   P                26     100     120     130
39   T                                                              -1     -87
40   W2               .12
41   X                         1
42   K         1     LTTLLK                                         1
43   K1            ROUTE HYDROGRAPH THROUGH LITTLE LAKE
44   Y                                 1       1
45   Y1        1                                                  -778      -1
46   Y4      778   778.5   779.1   780.5   781.6   782.5   783.2   783.9   784.5   785.1
47   Y4    785.6   786.1   786.5   787.0   787.4
48   Y5        0      50     100     200     300     400     500     600     700     811
49   Y5      980    1288    1789    2750    3728
50   $A        0     1.5       4     4.5       6     8.5      15
```

B-10

```
51   $E      765     770     778     780   784.7     790     800
52   $$      778
53   $D    784.7
54   $3       10      .5     774       1     778   784.7
55   K               SNRSLK                                         1
56   K1            RUNOFF CALCULATION FOR SUNRISE LAKE DAM DRAINAGE AREA
57   M         1       2      .7              .7       1                             1
58   P                26     130     120     130
59   T                                                              -1     -87
60   W2               .29
61   X                         1
```

```
K       3  SNPSLK                                                      1
K1         COMBINE ROUTED HYDROGRAPHS FROM BIG AND LITTLE LAKES WITH RUNOFF
K       1  SNRSLK                                                      1
K1         ROUTE HYDROGRAPH THROUGH SUNRISE LAKE
Y                                 1       1
Y1      1                                               -739      -1
Y4    739   739.2   739.4   739.7   740.2   740.5   740.9   741.2   741.6   741.9
Y4  742.3   742.6     743   743.2   743.7     744   744.7   745.4   746.1   746.9
Y5      0      11      57     123     252     356     535     689     891    1053
Y5   1317    1509    1825    2050    2449    2769    4054    6139    8771   12197
$A      0     1.5     7.5      23    27.5      32      42    51.5
$E    715     720     730     739     740   742.1     750     760
$$    739
$D  742.1
$B     10      .5     730       1     739   742.1
K            CLRLK                                                     1
K1         RUNOFF CALCULATION FOR CLEAR LAKE DAM DRAINAGE AREA
M       1       2     .34             .34       1                             1
P              26     100     120     130
T                                                         -1     -87
W2            .14
X                       1
K       2    CLRLK                                                     1
K1         COMBINE HYDROGRAPH ROUTED THROUGH SUNRISE LAKE WITH RUNOFF
K       1    CLRLK                                                     1
K1         ROUTE HYDROGRAPH THROUGH CLEAR LAKE
Y                                 1       1
Y1      1                                               -710      -1
Y4    710   710.5   710.7   711.2   711.5   711.9   712.2   712.6   712.9   713.3
Y4  713.6   714.1   714.3   714.7     715   715.5   715.8   716.5   717.3     718
Y5      0      80     173     352     495     739     921    1221    1437    1787
Y5   2037    2482    2815    3436    3955    4997    5841    8231   11730   15213
$A      0       2       7      13      15      20    27.5    35.5
$E    685     690     700     710   713.5     720     730     740
$$    710
$D  713.5
K      99
```

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	799.00	799.00	802.90
STORAGE	97.	97.	160.
OUTFLOW	0.	0.	1039.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	804.77	1.87	200.	4718.	.81	15.77	15.42
.50	803.50	.60	172.	2582.	.48	16.75	15.75

PLAN 1 STATION BIGLK

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	4192.	749.6	15.92
.50	2379.	747.1	16.75

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	778.00	778.00	784.70
STORAGE	24.	24.	57.
OUTFLOW	0.	0.	737.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	786.67	1.97	69.	2187.	.65	15.75	15.58
.50	784.15	0.00	54.	642.	0.00	15.92	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	739.00	739.00	742.10
STORAGE	175.	175.	262.
OUTFLOW	0.	0.	1185.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	745.86	3.76	391.	11029.	3.58	16.00	12.92
.50	743.14	1.04	296.	4209.	2.31	16.08	14.58

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	710.00	710.00	713.50
STORAGE	144.	144.	193.
OUTFLOW	0.	0.	1954.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	717.50	4.00	259.	12721.	5.58	16.00	0.00
.50	715.45	1.95	224.	4893.	3.08	15.83	0.00

PERCENT OF PMF ROUTING
EQUAL TO SPILLWAY CAPACITY

```
***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  01 APR 80
***********************************
      A1       DAM SAFETY INSPECTION - MISSOURI
      A2          CLEAR LAKE DAM (MO.30437)
      A3          PERCENT PMF
      B    300       0       5       0       0       0       0       0      -4       0
      B1     5
      J      1       4       1
      J1    .1      .2      .3      .4
      K          BIGLK                                       1
      K1       RUNOFF CALCULATION FOR BIG LAKE DAM DRAINAGE AREA
      M      1       2     .42             .42       1                       1
      P             26     120     120     130
      T                                                     -1     -87
      W2           .14
      X                      1
      K      1   BIGLK                                       1
      K1       ROUTE HYDROGRAPH THROUGH BIG LAKE
      Y                              1       1
      Y1     1                                            -799      -1
      Y4   799   799.2   799.4   799.7   800.1   800.4   800.8   801.1   801.5   801.7
      Y4 802.1   802.4   802.8   803.0   803.4   803.7   804.1   804.4   805.1   805.9
      Y5     0       4      23      52     110     159     246     315     432     521
      Y5   670     780     964    1113    1464    1815    2451    3117    5119    7994
      $A     0     1.5     4.5      10    14.5    20.5      27    33.5
      $E   770     780     790     799     800   802.9     810     820
      $$   799
      $D 802.9
      $B    10      .5     784       1     799   802.9
      K      1   BIGLK                                       1
      K1       STREAM ROUTING OF HYDROGRAPH TO SUNRISE LAKE
      Y                              1       1
      Y1     1
      Y6   .08    .045     .08     740     800    2000    .002
      Y7     0     800     200     780     360     760     480     740     520     740
      Y7   650     760     640     780     840     800
```

B-17

```
K          LTTLLK                                                  1
K1        RUNOFF CALCULATION FOR LITTLE LAKE DAM DRAINAGE AREA
M       1       2     .19              .19       1                                   1
P              26     100     120     130
T                                                                 -1     -87
W2            .12
X                       1
K       1  LTTLLK                                                  1
K1        ROUTE HYDROGRAPH THROUGH LITTLE LAKE
Y                                1       1
Y1      1                                                       -778      -1
Y4    778   776.5   779.1   780.5   781.6   782.5   783.2   783.9   784.5   785.1
Y4  785.6   786.1   786.5   787.0   787.4
Y5      0      50     100     200     300     400     500     600     700     911
Y5    980    1288    1789    2750    3728
$A      0     1.5       4     4.5       6     8.5      15

$E    765     770     778     780   784.7     790     800
$S    778
$D  784.7
$B     10      .5     774       1     778   784.7
K          SNRSLK                                                  1
K1        RUNOFF CALCULATION FOR SUNRISE LAKE DAM DRAINAGE AREA
M       1       2      .7               .7       1                                   1
P              26     100     120     130
T                                                                 -1     -87
W2            .29
X                       1
```

```
K       3  SNRSLK                                               1
K1        COMBINE ROUTED HYDROGRAPHS FROM BIG AND LITTLE LAKES WITH RUNOFF
K       1  SNRSLK                                               1
K1        ROUTE HYDROGRAPH THROUGH SUNRISE LAKE
Y                                 1       1
Y1      1                                               -739     -1
Y4    739   739.2   739.4   739.7   740.2   740.5   740.9   741.2   741.6   741.9
Y4  742.3   742.6     743   743.2   743.7     744   744.7   745.4   746.1   746.9
Y5      0      11      57     123     252     356     535     689     891    1053
Y5   1317    1509    1625    2050    2449    2769    4054    6139    8771   12197
$A      0     1.5     7.5      23    27.5      32      42    51.5
$E    715     720     730     739     740   742.1     750     760
$$    739
$D  742.1
$B     10      .5     730       1     739   742.1
K          CLRLK                                                1
K1        RUNOFF CALCULATION FOR CLEAR LAKE DAM DRAINAGE AREA
M       1       2     .34             .34       1                               1
P              26     100     120     130
T                                                         -1     -67
U2            .14
X                       1
K       2  CLRLK                                                1
K1        COMBINE HYDROGRAPH ROUTED THROUGH SUNRISE LAKE WITH RUNOFF
K       1  CLRLK                                                1
K1        ROUTE HYDROGRAPH THROUGH CLEAR LAKE
Y                                 1       1
Y1      1                                               -710     -1
Y4    710   710.5   710.7   711.2   711.5   711.9   712.2   712.6   712.9   713.3
Y4  713.6   714.1   714.3   714.7     715   715.5   715.8   716.5   717.3     718
Y5      0      80     173     352     495     739     921    1221    1437    1787
Y5   2237    2482    2815    3436    3955    4597    5941    8231   11730   15213
$A      0       2       7      13      15      20    27.5    35.5
$E    685     690     700     710   713.5     720     730     7[illegible]0
$$    710
$D  713.5
K      99
```

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	799.00	799.00	802.90
STORAGE	97.	97.	160.
OUTFLOW	0.	0.	1039.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	800.63	0.00	115.	208.	0.00	16.00	0.00
.20	801.62	0.00	135.	483.	0.00	15.92	0.00
.30	802.39	0.00	150.	775.	0.00	15.92	0.00
.40	803.02	.12	163.	2412.	.27	16.83	15.83

PLAN 1 STATION BIGLK

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	194.	741.3	16.25
.20	436.	742.9	16.17
.30	739.	743.8	16.08
.40	2192.	746.9	16.83

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	778.00	778.00	784.70
STORAGE	24.	24.	57.
OUTFLOW	0.	0.	737.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	779.34	0.00	29.	117.	0.00	15.92	0.00
.20	780.76	0.00	36.	223.	0.00	15.92	0.00
.30	782.04	0.00	42.	349.	0.00	15.92	0.00
.40	783.16	0.00	48.	494.	0.00	15.92	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	739.00	739.00	742.10
STORAGE	175.	175.	262.
OUTFLOW	0.	0.	1185.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	740.93	0.00	226.	549.	0.00	16.33	0.00
.20	742.15	.05	264.	1993.	.33	17.17	16.17
.30	743.10	1.00	295.	2767.	.98	16.75	15.75
.40	743.82	1.72	319.	3905.	1.67	16.50	15.50

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	710.00	710.00	713.50
STORAGE	144.	144.	193.
OUTFLOW	0.	0.	1954.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	711.72	0.00	167.	627.	0.00	16.42	0.00
.20	713.47	0.00	193.	1925.	0.00	17.25	0.00
.30	714.35	.85	206.	2687.	1.67	16.75	0.00
.40	715.09	1.59	218.	4152.	2.58	16.50	0.00